DOCUMENT RESUME

ED 280 735 SE 047 899

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TITLE Human Development and Evolution and Biology Teaching. Science and Technology Education Document Series No. 15.
INSTITUTION United Nations Educational, Scientific, and Cultural Organization, Paris (France). Div. of Science, Technical and Environmental Education.
REPORT NO ED-85-WS-43
PUB DATE Jul 85
NOTE 96p.; Line drawings illustrate the text.
AVAILABLE FROM UNESCO, 7 place de Fontenoy, 75700 Paris, France.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Biology; Embryology; Evolution; Foreign Countries; *Human Body; International Educational Exchange; *Physical Development; Science and Society; Science Curriculum; Science Education; *Science Instruction; Scientific Concepts; Secondary Education; *Secondary School Science; Technology
IDENTIFIERS Brazil

ABSTRACT

Developed as part of a document series that focuses on science and technology teaching, this volume was produced under the auspices of the Commission for Biological Education of the International Union of Biological Sciences (CBE-IUBS). It serves to provide biology teachers and others concerned with secondary biology curriculum development with current reviews of biological topics and with suggestions and resources for incorporating the topics into courses. Contents addressed include: (1) the origin of the human individual (prenatal); (2) human development after birth; (3) variation, evolution and growth in human population; (4) a curriculum map; (5) suggestions for practical activities; and (6) an annotated list of resources. A list of references is also included. (ML)

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Human Development and Evolution and Biology Teaching

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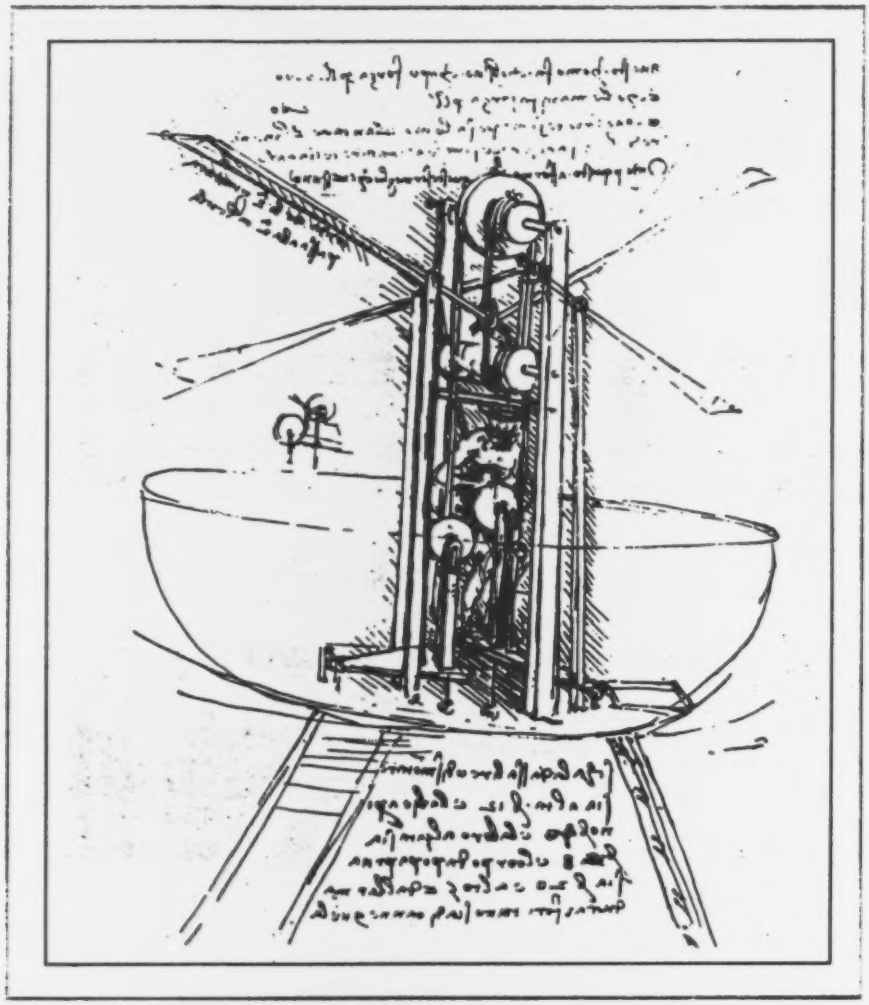

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SCIENCE AND TECHNOLOGY EDUCATION DOCUMENT SERIES NO. 15

HUMAN DEVELOPMENT AND EVOLUTION AND BIOLOGY TEACHING

Teresinha Burnham

Division of Science Technical
and Environmental Education
Unesco

Paris, July 1985

PREFACE

The document series has been initiated as part of Unesco's Science and Technology Education Programme to encourage international exchange of ideas and information on science and technology teaching. Through this it is further intended to develop greater awareness and better understanding of the nature of science and technology and their role in a changing society by improving and extending their teaching to in and out-of-school education. The present volume, as part of the "Biology and Human Welfare" theme was produced under the auspices of the Commission for Biological Education of the International Union of Biological Sciences (CBE-IUBS) under contract with Unesco. Under this theme, the overall aim of various booklets has been two-fold:

i) to provide biology teachers and others concerned with curriculum development in secondary biological education with comprehensive, yet not complex reviews of topics which illustrate the relevance of biology both to human societies and to individual human beings, and

ii) to provide suggestions and a guide to resources to help teachers incorporate the topics into their courses.

Dr. T. Burnham, Reader in Science Education at the University of Sao Paulo, Brazil, wrote the text, based on her practical experience of teaching and training teachers in Brazil. Mr. A.J. Pritchard, Department of Education, The University of Southampton, United Kingdom, contributed to and edited the whole text. Mr. D.J. Buckland of the same department also contributed to the text, and prepared the original drawings. The work was produced under the general supervision of Professor P.J. Kelly, Head, Department of Education, The University of Southampton.

The opinions expressed in the text are those of the authors and not necessarily those of Unesco.

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CHAPTER 1

THE ORIGIN OF THE HUMAN INDIVIDUAL

Conception results from the union of a sperm and an egg. The birth of a child marks only the end of the first stages of human development. The act of intercourse leading to fertilisation usually follows a commitment on the part of the man and woman to each other. In many parts of the world today couples use contraceptive methods as a means of planning the birth of children. It is now possible for human fertilisation to be effected artifically, by uniting sperms and eggs taken from individuals without intercourse occurring. This involves complex techniques which, so far, have only been used in a few countries on a very small scale. The adoption of such practices is a matter of cultural and moral considerations as well as biological understanding.

Basically, the formation of a new individual, is an interaction between two half-units of the human species - the sperm and the ovum. These are haploid cells, each having in its nucleus half the number of chromosomes found in the body cells of each parent. When these haploid cells fuse, they form a zygote with 23 pairs of chromosomes. The genes contained in these chromosomes contain the information necessary for the development of the new individual. They constitute its genotype. A genotype represents half of each parent, a quarter of each grandparent, an eighth of each great-grand-parent, and so on. These are combined in different ways and contribute to the individual uniqueness of each person.

Besides the recombination of the genes that form a genotype; individual uniqueness also results from the interaction between these recombined genes and the interactions between the individual as a whole and its environment. Due to these three processes, there is great variation in the human species.

The zygote, a single cell, becomes a multi cellular embryo by a process of successive divisions (cleavage). As this cleavage is taking place the mass of cells passes through the oviduct towards the uterus (Figure 1 page 3), swepted down by a fluid current set up by the cilia of the inner lining of the oviduct aided by muscular contractions of its wall. In this form of cell division (mitotic) each daughter cell obtains a full complement of chromosomes but until 16 cells are produced no increase in the size of the cell mass found in the original zygote has occurred. Also no differentiation of cells has occurred. However, as it enters the uterus the cell mass grows into a fluid-filled ball formed by two layers of cells (blastocyst) which eventually becomes fixed/ implanted to the wall of the uterus.

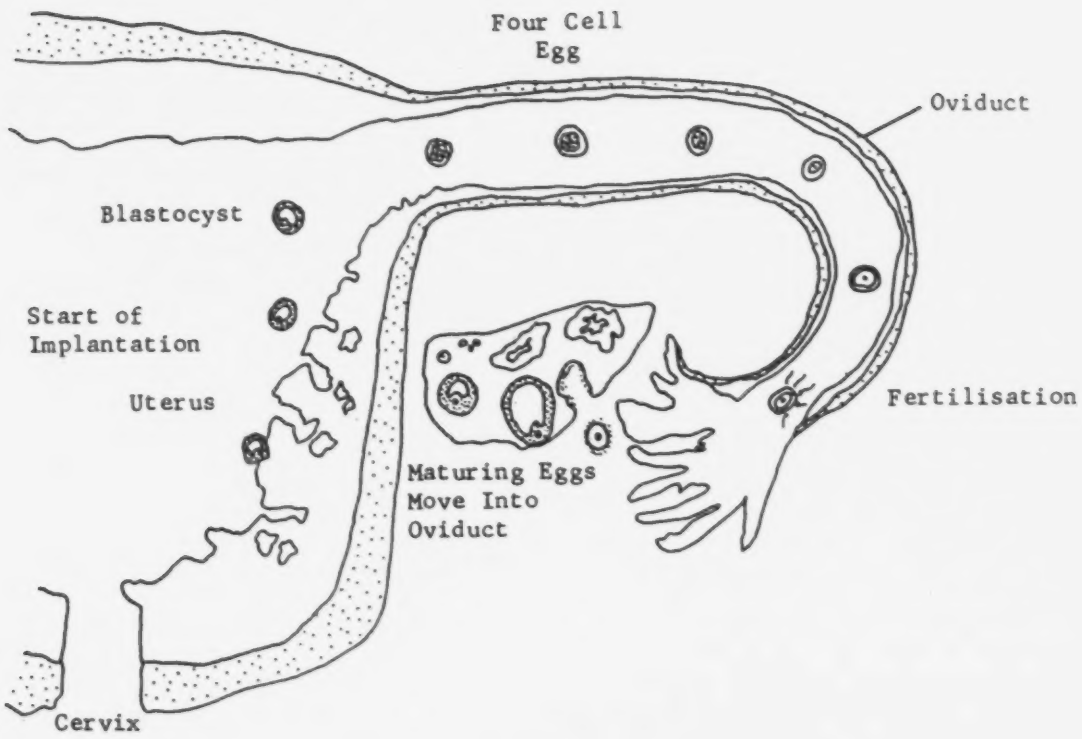

Figure 1 Sequence of events of fertilisation from ovulation to implanation

Earlier, after the egg had left the ovary, two chemicals (hormones) - oestrogen and progesterone - were secreted. These hormones stimulate the uterus to provide a hospitable environment for the embryo. Rising levels of oestrogen in the mother's blood stream leads to the development of the muscles of the uterus. Progesterone stimulates glands in the uterine wall to produce fluids rich in glycogen and enzymes necessary for the nutrition of the embryo. The combined action of oestrogen and progesterone stimulates the lower part of the uterus to produce a thick and sticky mucus which prevents bacteria entering.

A week after fertilization the blastocyst is increasing in size and its cells differentiating for various functions (Figure 2). Its inner layer of cells forms the embryo and the embryonic membranes. The outer layer (trophoblast) develops very quickly to anchor itself to the uterus wall and provide protection and nourishment to the embryo.

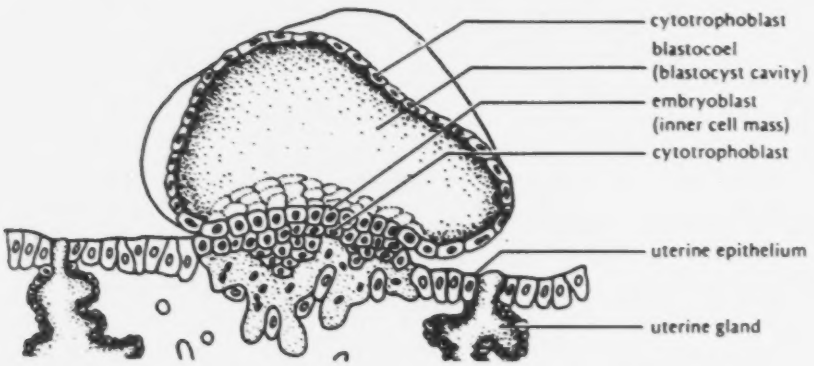

Figure 2 Embryonic Membranes
(Redrawn from Introduction to Embryonic Development. S. B. Oppenheimer, 1944)

It also starts to secrete a hormone - chorionic gonadotrophin - which stimulates the continued production of oestrogen and progesterone.

In parallel with the development of the trophoblast, the inner layer of the blastocyst forms a membrane - the amnion - around the young embryo. Gradually between the amnion and the embryo a cavity cavity - the amniotic cavity - develops. This is filled with a saline solution and acts as a shock barrier for the embryo, as well as preventing dessication. Another membrane - the chorion - develops from projections of the inner layer of the blastocyst which penetrate the trophoblast and into the uterine wall. The projections - villi - form a series of spaces in the uterine wall, which are filled in with the mother's blood. These spaces became larger and larger as the chorion gets thicker and develops deeper and deeper villi. Eventually, this whole structure will differentiate into the placenta through which the embryo will obtain food, respire and excrete (Figure 3).

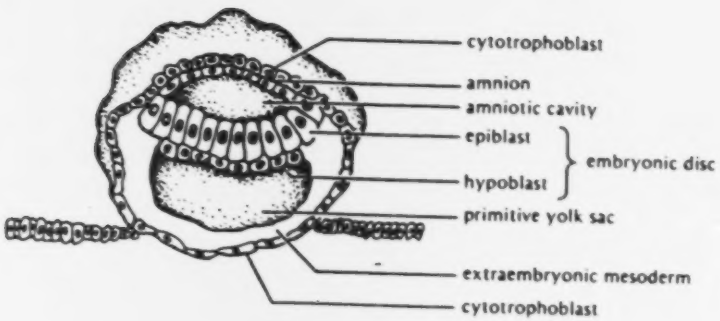

Figure 3 Development of Placenta
(Redrawn from Introduction to
Embryonic Development.
S. B. Oppenheimer, 1944)

Two other structures, the yolk sac and the allantois, also develop from the embryoblast (Figure 4 page 6). The functions are somehow obscure. The yolk sac provides nutrition for the embryo in its first days of development (Roze, 1976) but apparently no other functions. The allantois provides the blood vessels for the placenta and fuses with the chorion, forming a stalk. This stalk links the embryo to the chorion and later develops into the umbilical cord, whose function is to connect the embryo with the placenta.

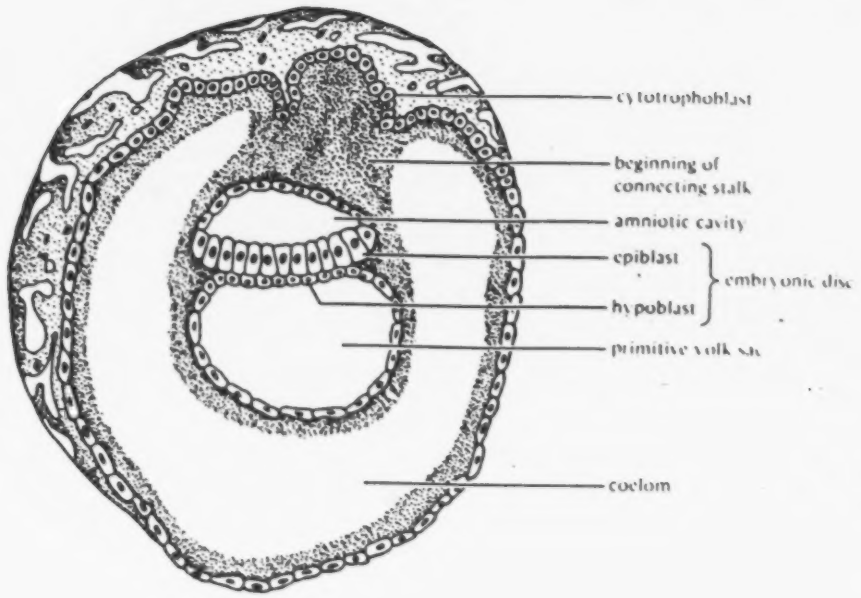

Figure 4 Human blastocyst at the end of the second week.

Up to this point the preparation of the conditions for ensuring protection and nourishment for the embryo has been faster than the development of the embryo itself. Now in the second week of its existence, with a suitable environment for its development, the process of differentiation in the embryo speeds up.

The process of cell differentiation depends on the production of specific types of proteins responsible for particular characteristics of the cells. By a still unknown mechanism, genes in particular cells responsible for the production of certain proteins become active, while others responsible for other kinds of proteins remain dormant. For example, some indifferentiated cells may have the genes responsible for the production of muscle proteins turned on, so that they will become differentiated muscle cells; other undifferentiated cells will produce nerve proteins because the genes responsible for the synthesis of these will be turned on and differentiated nerve cells will be formed. If genes are absent or abnormal the process of differentiation will be upset and disorders such as Tay-Sacks disease and phenylketonuria will result.

By the third week the embryo consists of three layers of cells. During the fourth week the embryo undergoes a process of folding. This folding is very important for the formation of spaces where organs are going to develop (Figure 5). The embryo at this stage is converted into a tubular body with two internal cavities. One is the coelomic cavity which will become the thoracic and the abdominal cavities. The other is the primitive gut, a tube suspended in the centre of the embryo the ends of which will eventually open and become, respectively, the mouth and anus. The anterior portion of this tubular body grows, forming the head; the trunk starts to take shape; the precursors of the brain and the rest of the nervous system, as well as the heart start developing.

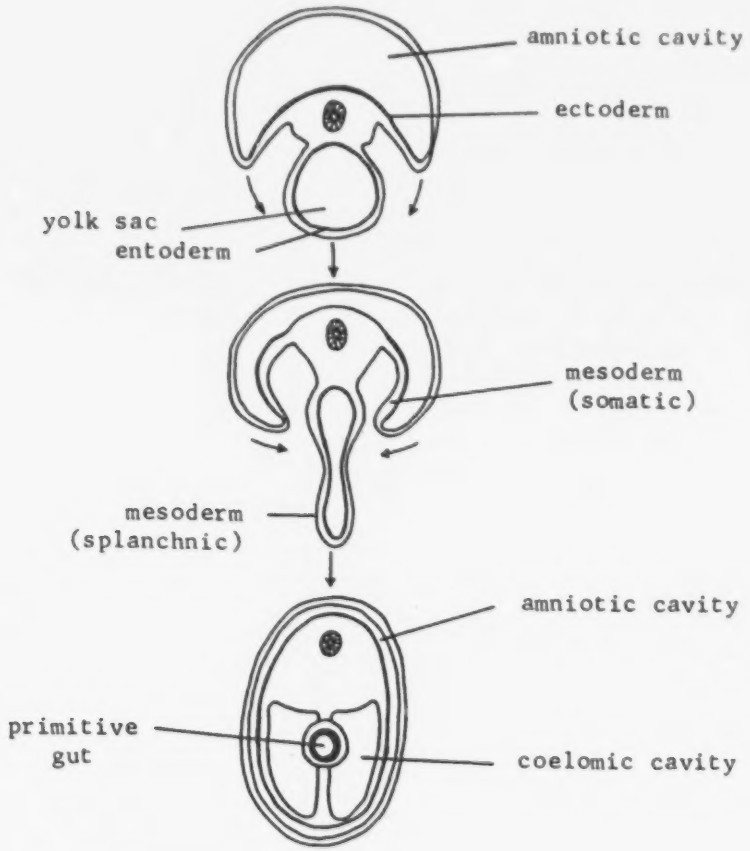

Figure 5 The embryo undergoes a process of folding during the fourth week to form the coelomic cavity and primitive gut.

By the fifth week the different systems of the body begin the process of development. The outer layer - ectoderm - of the embryo contributes to the formation of the skin (except the dermis) and the nervous systems. The middle layer - mesoderm - forms the bones, muscles, heart, blood cells and blood vessels, kidneys, gonads, and the dermis of the skin. The inner layer - endoderm - develops into the digestive tract, lungs, trachea and larynx, liver, pancreas, bladder and urethra, and vagina. The external features of the embryo at this time include the limb buds from which originate the arms and legs, and the rudement, the ear, eye and nose of the face.

According to Luciano, et al (1978), it is in the first five weeks of embryonic development that congenital malformations are more likely to arise. The occurrence of these malformations, their type and extent depends on the stage of development at which the embryo is exposed to the harmful influences. In the earlier stages of embryonic development non-specialised cells are transformed into specialised cells. If the undifferentiated cells are exposed to drugs, viruses or radiation, for example, they may be destroyed or altered so that they eventually form defective tissues or organs.

By the end of the fifth week the embryo is about 1.25 cms long and the placenta is functioning fully as a respiratory, nutritive and excretory organ. Through this structure the mother provides nutrients, gases and chemicals giving the embryo immunity from diseases, and the embryo discards its waste. Selective exchange of hormones between mother and embryo also take place through the placenta. The importance of the placenta is such that Kastenbaum (1979) says that non-genetic influences on the intrauterine development of a child can be discovered through the study of what can, and what cannot, pass through it from the mother to the child. (See figures 6 and 7 pages 13 and 14)

By the end of the sixth week the embryonic nervous system and muscles are developed but not yet well co-ordinated and the majority of the internal organs are differentiated. During the seventh week the outer ear is formed, the inner ear is almost completed and the upper lip becomes the first sensitive part of the body to develop (Stine, 1977). The embryo has a clear human appearence during the eighth week. The external features of the face, arms, legs, fingers and toes, including foot and palm prints, are established. All the adult organs are formed and the first bone cells replace cartilage. The embryo now is considered to be a foetus, weighs about 2.25 grams, is approximately 2.5 cms long and begins to respond to mild stimulation. By this stage the change in the process of feeding from digesting tissue in the uterine wall to absorbing nutrients filtered through the placenta has speeded up the growth of the foetus considerably.

By the end of the third month the foetus weighs about 28 grams and measures 7.6 cms. The head is one third of the total body. The four month old foetus weighs about 110 - 150 grams and is 15 cms long. During this time the organs continue to develop

into functioning systems. The sexual structures, until now bipotential, differentiate into either a male or female system. Brain development enables the foetus to move spontaneously and the whole body (except the back and top of head) is sensitive to touch. Reflexes of grasping and fanning, and extending the toes (Babinski reflex) are exhibited.

At this stage the physiological inter-relation between mother and foetus is sensitive and complex. Since the third month the placenta, besides most of the oestrogen and progesterone found in the mother's body, has produced other hormones as well. These hormones play an important role in the metabolism of fats and in maintaining the balance of proteins and glucose in the mother's blood plasma. These functions are absolutely vital for the continuation of the healthy development of the foetus.

The mother's metabolic rate and food intake have to increase a great deal to meet the nutritional demands of the foetus. If they are deficient it can lead to the birth of babies with low birth weights and consequently a high rate of infant mortality, high risks of mental and motor impairment and several types of complications after delivery (Newman and Newman, 1978). Lack of protein in a pregnant woman's diet has been shown to affect a child's mental development (Davidson and Dobbing, 1966). In 1974 Habicht et al. presented the results of a study undertaken in Guatemala which showed the effects of diet on babies' birth weight. A group of women who were able to supplement the amount of calories in their diet during pregnancy gave birth to babies 200 grams on average heavier than those born to mothers without supplemented diet.

The more the foetus grows and develops physically, the more organised become its actions. The development of patterns of actions is linked with the differentiation of the sensory-receptors and is called behavioural differentiation (Kastenbaum, 1979). By the end of the sixth month these receptors are well established and the foetus responds to touch by muscle movements, and to taste by sticking out the tongue (Newman and Newman, 1978). However, responses to sound are not observed until the eighth or ninth month, as the external ear canal is filled with amniotic fluid. The sense of smell is not present probably until birth, because the nostrils are full of skin cells until the sixth month and, when these cells eventually are dissolved away, their space is taken by amniotic fluid. Reaction to light is possible since the sixth month when the connection between the retina and the brain is established. Babies born prematurely at the sixth month show this (Newman and Newman, 1978).

Also changes occur in the mother's body. The uterus, stretching into the abdominal cavity, pushes gradually against the diaphragm and the ribs. The mother's profile changes as her abdomen grows. The breasts enlarge markedly due to hormonal stimulation. Oestrogen activates the storage of fat and the development of the network of mammary ducts whilst progesterone activates the development of the lobules where the alveoli

responsible for the production of milk are formed. The breasts are now fully prepared to function as the baby's first source of food.

In the mother's blood plasma the levels of sodium and water increase. As a consequence she may have increased blood pressure (Hypertension) and increased levels of protein excreted in the urine. When these levels are very high they can have a toxic effect. This condition can be prevented and controlled by the restriction of salt in the pregnant women's diet.

The foetus is physically prepared to live as an individual after the end of the sixth month. However, if it is born at this time very often it is unable to survive. Several reasons are given for this. One is that the nervous system has not yet developed sufficiently to co-ordinate vital functions, such as the breathing rhythm, peristalsis of the gut, body temperature, and the control of muscle tone, and to allow actions, such as swallowing, sucking, head movements and hand grasping, to be fully performed. Another important reason for the innability to survive at this stage is that the baby lacks antibodies to protect it against most diseases. Such antibodies, produced by the mother, are kept out of the foetus system by the placenta until the last month of pregnancy.

At the end of six months, the foetus is, on average, 30.5 cms long, weighs 900 grams, has the first fat deposits under its skin and has its eyes open. Its height and weight measurements increase to 40.5 cms and 1800 grams in the seventh month and 51 cms and 3200 grams during the ninth month.

Foetal development is not affected solely by the physical interactions that take place in the uterus. It is also influenced by the age, health and psychological condition of the mother and indirectly by conditions in the external environment which effect her.

The age of the mother appears to be very influential on foetal development. Premature babies are likely to be born from very young mothers (15 to 19 years of age) or from much older ones (over 35). One third of babies with Down's syndrome (mongolism) were born to mothers over 40 years of age according to a study reported by Reed (1975).

Undernourished mothers give birth to low weight babies. Mothers affected by rubella, for example, are likely to have babies defective in sight, hearing and speech. Infections in the mother caused by cytomegalovirus leads to children with a reduced number of blood platelets (thrombocytopenia), hepatitis and, infrequently, meningoencephalitis. Mothers with tuberculosis, syphilis or malaria tend to have premative births (Battaglia and Simmons, 1978).

When a pregnant woman takes some kinds of drugs (sometimes to treat ill-health or stress), it can have deleterous effects on the foetus. Stine (1977) lists 26 drugs, including some in common use e.g. aspirin, quinine, iodine and reserpine, which affect foetal development. A considerable number (over 6000 referred to by Stine) of children were born with abnormalities of the hands, arms, feet and legs, due to use of thalidomide by their mothers. Alcohol and nicotine have been related to temporary changes in the state of the foetus (acceleration of heart rate and activity level). Smoking by mothers has been related to small foetal size (Guttmacher, 1962), low birth weight (Meredith, 1975) and premature birth (Simpson, 1957). Annis (1978) showed that delays in postnatal development are found more often in babies whose mothers smoked during pregnancy. Effects of alcohol on prenatal development have been reported in studies referred to by Battaglia and Simmons (1978) who point to several abnormalities in babies born to mothers with chronic alcoholism.

The psychological state of the mother also has influence upon foetal development. Positive attitudes of mother towards pregnancy appear to be beneficial for the growth of the child. Where these attitudes have family and community support, then influence on the child appear greater. Negative attitudes are likely to produce anxiety, irritability and dependence in the mother. These states cause changes in the physiological balance of the woman and influences the uterine environment and thus the foetus. Stott (1971) has demonstrated links between psychological stress during pregnancy, due to illness or matrimonial problems for example, and problems in the offspring, such as ill-health, congenital malformation and mental retardation. These problems are probably related to the effect that hormones produced in excess during stress may have on foetal activity, tension and emotionality (McDonald, 1968; Ferreira, 1965a, b; Kelly, 1962).

Environmental influences on pregnancy cover a wide range of agents and effects, from the availability of sources of food for a balanced diet, to the effects of radiation and chemicals. According to Stine (1977) a number of sources of radiation can effect foetal development. For example it has been estimated that in the United States alone some 46,000 deaths in future generations may be caused by genetic damage caused by X-rays used for medical purposes. A number of chemical substances have also been identified as causes of genetic damage through tests carried out on non-human organisms. It is possible that they could effect foetal development in human beings. Among these chemicals are some found in food preservatives, artificial sweeteners, food colouring, pesticides, and tranquilisers, commonly used in a number of countries.

A report issued by the Department of Health, Education and Welfare (USA), in 1974, indicated that 15 million of Americans had their daily lives directly affected by one or more birth defects. 3 million of these cases were due to environmental causes; 9 million due to a combination of hereditary and environmental factors (Stine, 1977). This provides some estimate of the problem societies have to face. A great deal has yet to be learned about prenatal development, particularly concerning the interactions between foetus and mother. The number of factors involved in this interaction is enormous and probably science is still at a stage of scratching the surface of the issue. However, it is important to bear in mind that. our present knowledge enables us to assist the early lives of children more than we do. Healthy and happy children depend a great deal on the support that they receive from the very beginning of their lives.

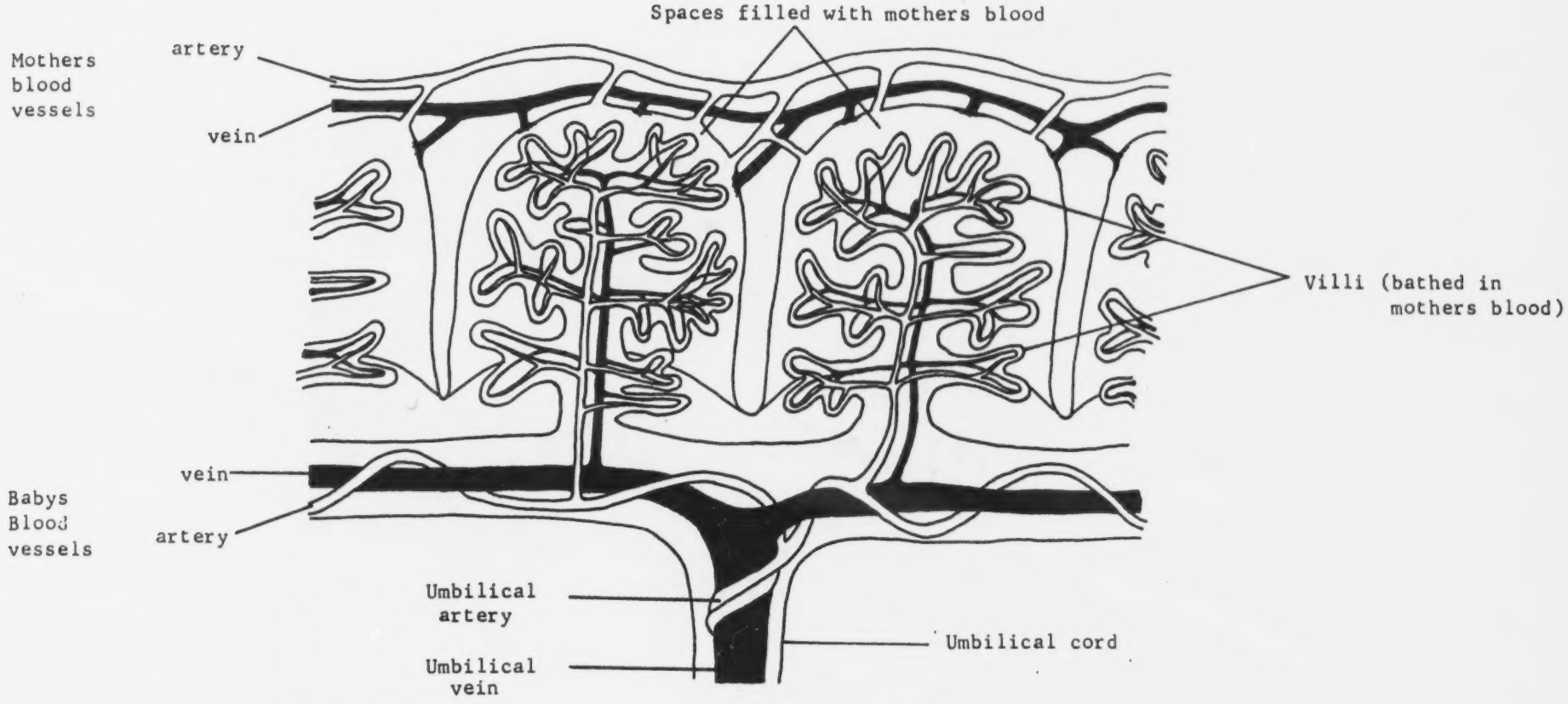

Figure 6 Structure of the Placenta

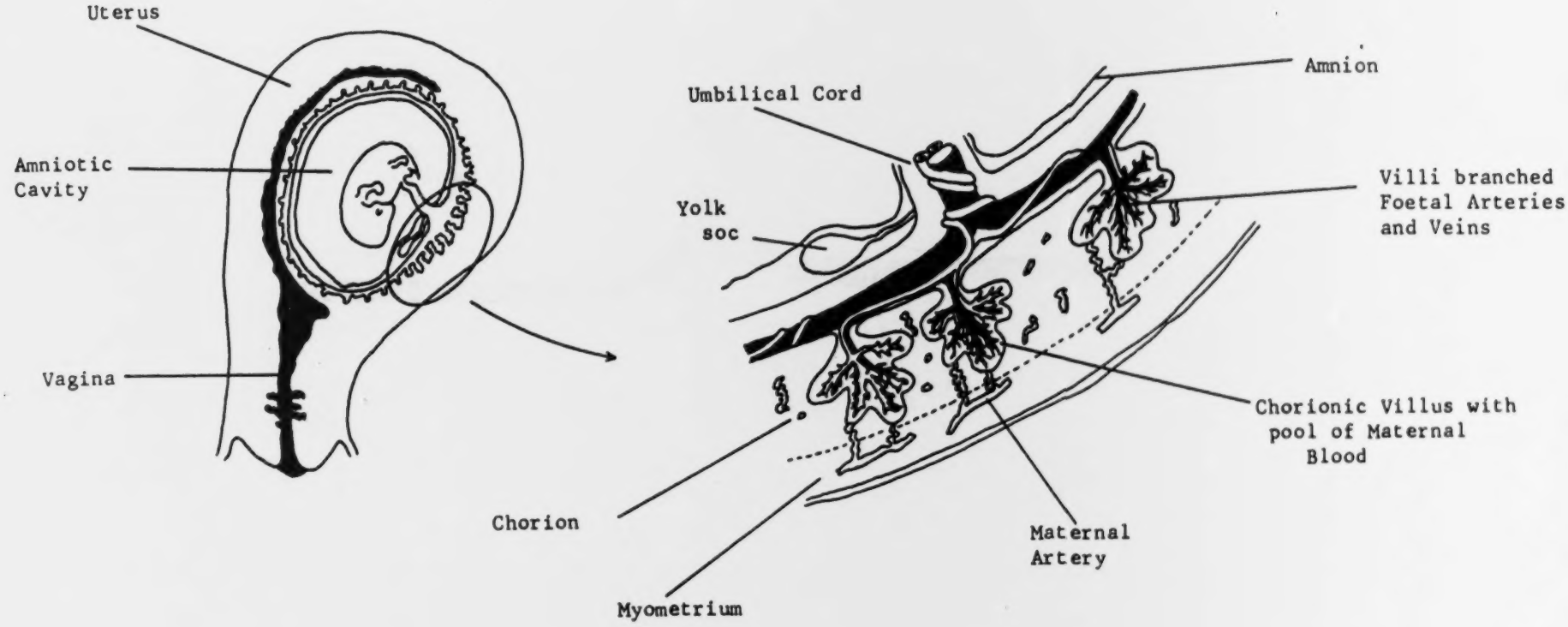

Figure 7 The Placenta

CHAPTER 2

HUMAN DEVELOPMENT

The development of an individual after birth involves the slow and complex processes initiated in intrauterine life. An overview of these processes linked to metabolism, physical growth, cognitive and psycho-social development is discussed in this chapter.

Birth brings the child from the limited and balanced uterine environment into an open and complex one. From the beginning this environment imposes a large number of variable conditions on the newborn. The first breaths provoke a large pressure in the thorax with the rapid expansion of the lungs. The blood flow in the lungs increases; oxygenated blood is pushed into the various parts of the body and returns to the lungs for gas exchange. This circulation is vital for the control of body temperature, particularly at the surface. The baby in the open environment meets a much lower temperature than that of the uterus. Oxygen is used up in a series of reactions producing energy (metabolism) that keeps the baby warm. One important reserve of energy that the newborn brings with him/her into the world is a layer of brown fat. This fat is found in the neck, axillae, between the shoulder blades and other internal parts of the body. It is used for the maintenance of body temperature until replaced by more advanced mechanisms, such as shivering. The brown fat is a mechanism to compensate for a functional immaturity.

Other inefficiencies however, pose more of a problem as in the case of bilirubin excretion. This substance is a product of haemoglobin breakdown and is found in newborn's serum at higher levels of concentration than at any other time in life (Battaglia and Simmons, 1978). This is probably due to a higher rate of red cell breakdown and a higher level of haemoglobin in the baby's blood stream. The excretion of bilirubin requires the action of an enzyme the newborn is unable to produce in sufficient quantity for the elimination of all the excess bilirubin. As a consequence, the newborn (particularly premature baby) is likely to develop jaundice during the first week. Sometimes brain damage (kernicterus)[1] may result from this excess of bilirubin.

After birth the baby loses the state of chemical and physical balance - i.e., homeostasis - provided by placental exchanges. From this is a quick and substantial change that requires some adjustment. From the beginning the baby is able to digest and absorb protein and

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(1) In some babies the deficiency in the induction of this enzyme is genetic and causes hereditary jaundice. This can be treated by a drug called phenobarbital (Hamilton, 1972). Physiological jaundice can be treated by phototherapy.

sugars from milk, (only ten percent of these substances are wasted (Carter, 1980)). However, fat is not absorbed as well until the sixth to the eighth week after birth. This is probably due to the inadequate production of substances which help in the digestion of fat (bile and lipase, by the liver and pancreas, respectively). Breast feeding has advantages in this case; human milk has fats which are easier to digest than cow's formula milk and also contains two lipases (enzymes) as compared with one in formula milk (Knitle, 1978).

The metabolism of milk produces waste or excesses which have to be discarded from the body; in the carrying out of this function the kidneys are essential. The sodium, phosphate and proteins contained in the milk are absorbed and concentrated in the blood plasma. The kidneys have to regulate the excretion of the surplus plasma components with the water balance in the body. This is difficult because a baby needs and excretes more fluid than adults and yet he/she cannot control the level of fluid intake. (Figure 8) The exretion of sodium excess in the first months is limited; consequently, if babies are not given plenty of liquid they may have oedemas - a result of surplus sodium in the blood plasma. An investigation carried out in England, by Smith (1974 referred to by Carter, 1980), showed that in a sample of bottle feeds brought by mothers to a clinic, 57% were overconcentrated in sodium. Overconcentrated milk, according to Carter (1980) may lead to high concentration in the plasma, increased water loss and dehydration as shown in Figure 9. Breast-fed babies experience no difficulty in eliminating minerals excess because human milk has a low concentration of these substances (Figure 10). Formula milk also contains higher concentrations of phosphate and the newborn's kidneys are not mature enough to filter phosphate out of highly concentrated plasma. This inadequate filtration provokes another problem: phosphate and calcium are reciprocally related in their concentrations; when phosphate is high calcium is low, and a low level of calcium causes fits and neuro-muscular excitability (tetania) in babies. These problems are virtually unknown in breast-fed babies (Carter, 1980).

The change from milk to solids means a rapid increase in the number of enzymes produced by the brush border of the intestine. Lipases and bile salts are produced in higher quantities, so reducing, by the third month, the incidence of fat malabsorption. However, full efficiency of fat absorption of nutrients decline during the first year as compared with the milk-feeding period. This may be due to the rapid gut-transit, causing high proportions of dietary energy to be wasted. This is observed as undigested pieces of begetables with tough cellulose envelopes (such as carrots, peas, sweet corn) which appear in the stools of young infants. This decline does not have to impair growth or health for there is an alternative to ensure more efficient meals that is to mash or finely chop the infant's food.

As the infant grows older absorption efficiency becomes higher but this can be hindered by his/her susceptibility to gastro-intestinal infections. The immaturity of the infant's defence system, lack of hygiene in bottle preparation, indiscriminate eating by the infant and ingestion of contaminated food and water are some of the factors which prompt the appearance of these types of infections.

	4 kg Infant	Adult
Approx. ECF volume (% of body weight)	45	20
Approx. daily fluid intake (ml/kg)	150	30
Approx. daily insensible fluid losses (ml/m^2)	285	200

Figure 8 Comparison of ECF Volume, Fluid-Intake and Insensible Losses in the Young Infant and Adult
(Reprinted from Carter, 1980)

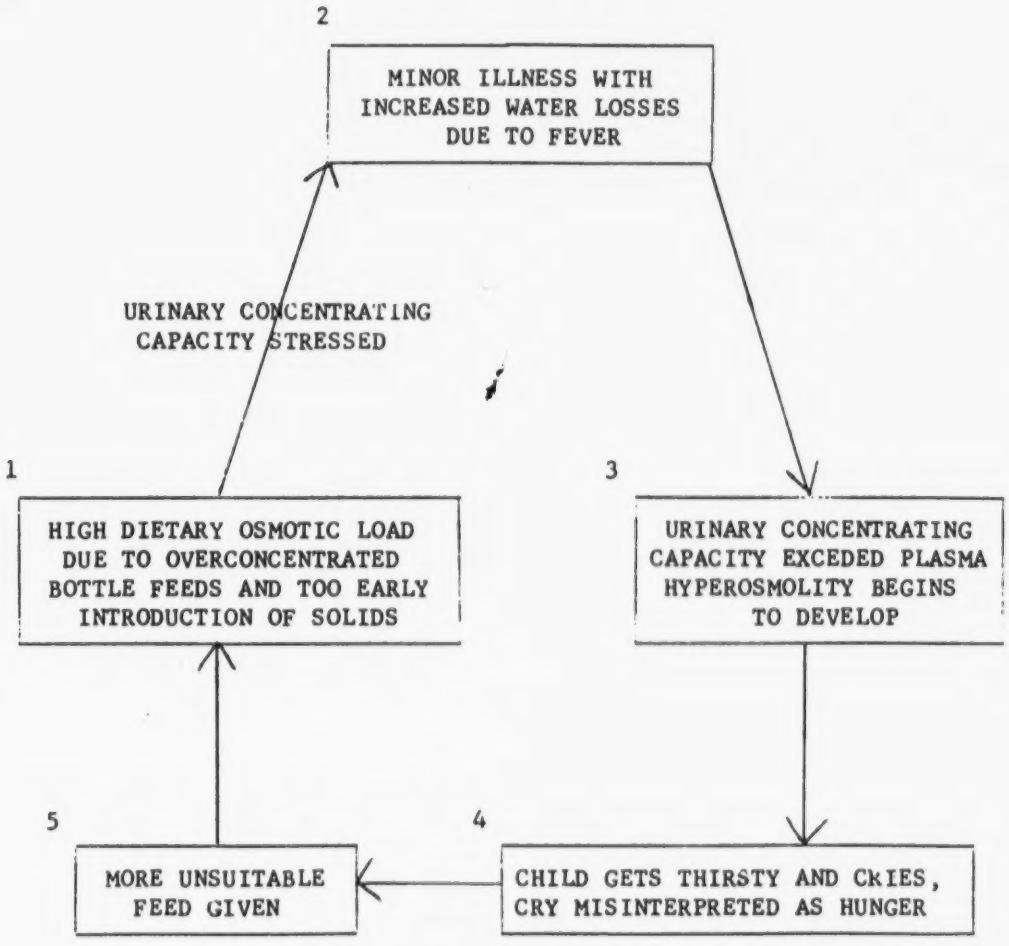
2
MINOR ILLNESS WITH INCREASED WATER LOSSES DUE TO FEVER
URINARY CONCENTRATING CAPACITY STRESSED
1
HIGH DIETARY OSMOTIC LOAD DUE TO OVERCONCENTRATED BOTTLE FEEDS AND TOO EARLY INTRODUCTION OF SOLIDS
3
URINARY CONCENTRATING CAPACITY EXCEDED PLASMA HYPEROSMOLITY BEGINS TO DEVELOP
5
MORE UNSUITABLE FEED GIVEN
4
CHILD GETS THIRSTY AND CRIES, CRY MISINTERPRETED AS HUNGER

Figure 9 Pathogenesis of Hyperosmolar Dehydration
(Reprinted from Carter, 1980)

		Human	Cow	Modern Formula
Protein	(g)	1.2	3.3	1.5
Sodium	(mg)	15	58	26
Potassium	(mg)	55	138	75
Calcium	(mg)	33	125	62
Phosphate	(mg)	15	96	43
Osmolality	(mOsmol/kg)	79	200	104

* per 100 ml unless otherwise stated

Figure 10 Protein, Major Minerals and Osmolality of Various Milks*
(Reprinted from Carter, 1980)

The energy requirements of the young child are very high for two main reasons: k cellular metabolism is higher than in adults and the relatively large brain consumes a great deal of energy. Heat loss is high due to the large surface area of the body and the loss of dietary energy in the stools. The building up of bones and muscles requiring large quantities of protein, cellular reproduction for the development of new tissue, and body activity make growth demanding in terms of energy. The regulation of body temperature changes gradually from the metabolism of brown fat to shivering, by which time the skeletal muscles are the main source of heat production.

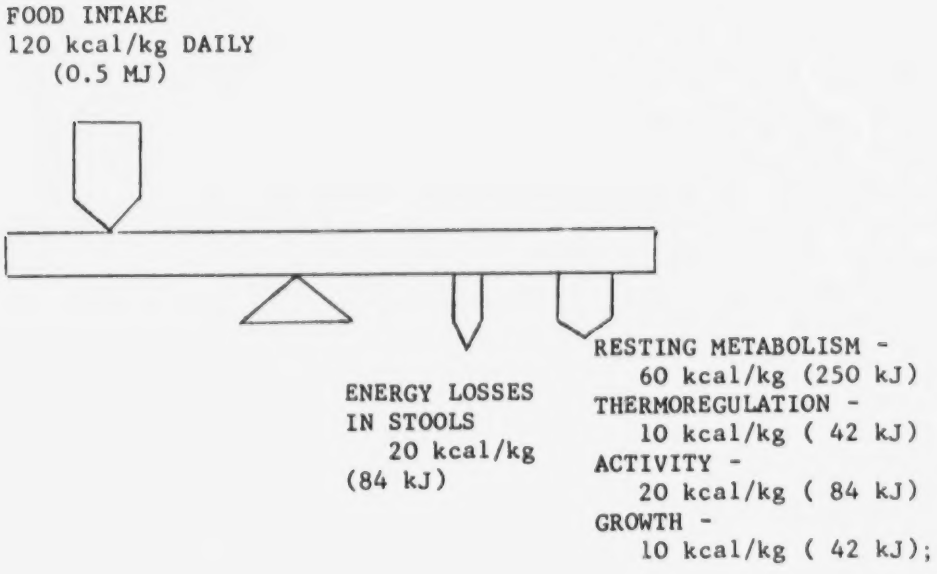

Figure 11 Energy Balance in the Young Infant
(Reprinted from Carter, 1980)

In the young child the energy intake is used in the carrying out of a number of different functions. (Figure 9)

Development involves the growth and maturation of systems which allow man to relate in an active way to other individuals and to the environment. Man is able to engage in sports, move from one place to another and dig the ground, thanks to his muscles and bones. These motor activities, in their turn, are dependent on the nervous system for co-ordination. The newborn is able to do very little until the interaction and co-ordination between muscles, bones and nervous system is established.

Skeletal muscles are formed by fibres which arise from the fusion of long, narrow, multinucleated cells called myoblasts. Until recently it was thought that a person at birth "already has all the skeletal muscle fibres it will ever have" (Luciano et al., 1978). However, studies pointed out by Brasel and Gruen (1978) reveal that the number of these muscle fibres increases after birth. The age at which the formation of new fibres ceases is not yet known but there is evidence to suggest that muscles grow in mass and in number of nuclei[1] throughout postnatal life until adolescence. Deficiency in growth-hormone as well as under-nutrition in immature human individuals influences skeletal muscle growth, reducing muscle mass and nuclear number. Overnutrition in early childhood has the opposite effect, according to studies referred to by Brasel and Gruen (1978).

Muscles also develop in strength, from early childhood to around fifteen (in girls) and twenty (in boys) years of age. This strength is influenced by external factors, such as physical activity, particularly training. This is evident in people whose work requires a great deal of muscle effort such as digging, pulling, pushing and lifting (miners, farmers, weight lifters). Under-nutrition, in terms of poor diets in protein-calorie, lead to reduction of muscle mass, muscle cell size and, possibly, muscle strength (Malina, 1978). Bailey et al. (1978), reviewing the relationships between physical exercise and muscle growth, found that the majority of studies suggest that increase in muscle size due to exercise is caused entirely by hypertrophy (increase in cell size). However, he also points out that more recent findings suggest that this question is still open to debate, particularly in considering the early years of growth.

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(1) As muscle fibres are formed by fusion of many cells, it is not possible to determine the increase in size and in number of muscle cells as such. Two biochemical techniques have been developed to overcome this difficulty (Malina, 1978). One technique measures the mass of the fibres from the amount of a substance produced by muscle metabolism (creatinine). The other uses the content of DNA in the fibres as an index of "cell number". These techniques are still seen with some caution by scientist.

The development of the skeleton involves both, the growth and matufation of bones. The length of this process various from one bone to another. According to Luciano et al. (1978) the formation of the long bones is completed by the age of twenty. The growth of bones is due to an ongoing process of cell reproduction and transformation and follows a different pattern for the different types of bones. When babies are born their bones are partially ossified and partially formed by cartilage. In the case of long bones, the cells of the cartilaginous ends (epiphysis) reproduce, enlarge and begin to disintegrate. The intercellular substance gradually calcifies, replacing the disintegrating cartilage, and t the bone forms. Gradually more cartilaginous growth, disintegration and mineralisation enable the bone to grow further. However, ossification does not extend throughout the cartilaginous area - the ends of the bone remain as articular (joint) cartilages, and the region between the shaft (diaphysis) and the ossified epiphysis as a disc of cartilage. This disc is responsible for the elongation of the bone and persists until the bone reaches its adult length. (Figure 12) Increase in the bone width is due to the addition of new mineralised bone on the exterior surface of the shaft. This addition is the result of the activity of cells (osteoblasts) in the deep layer of the periosteum (a sheath of connective tissue surro surrounding the bone). At the same time bone is reabsorbed from the internal surface of the periosteum and the diameter of the narrow cavity enlarges (Roche, 1978).

The growth of bones may be influenced by diet. It is known that the lack of vitamin D in one's diet results in a decrease in calcium absorbtion and consequently the bone matrix fails to calcify properly, leading to rickets. In the Andes region of South America, for example, a large number of people are cretinous because their parents have an endemic thyroid problem - goitre, a result of a lack of iodine in their diet. These cretinous people show abnormal skeletal development, being dwarfs with abnormal skull forms, as described by Israel (1978). Israel also mentions studies carried out in the Middle East where dwarfism and other abnormal skeletal conditions are related to zinc deficiency and to geophagia (eating of earth). These latter cases are characterised by diminutive size and an immature appearance of the skull.

The nervous system's basic structure is formed by three cell types - the neuron, the neuroglia and the Schwann cells. The neuron is the basic unit of the neural tissue and has the function of transmitting messages in the form of electrical nerve impulses. Neuroglia (or glial cells) are smaller cells with different forms and different functions (some of which are still unknown). (Figure 13) One type of neuroglia forms the myelin coating of nervous fibres in the central nervous system. In the peripheral system this coating is formed by the Schwann cells which are also responsible for the enclosing of peripheral nerve fibres without myelin.

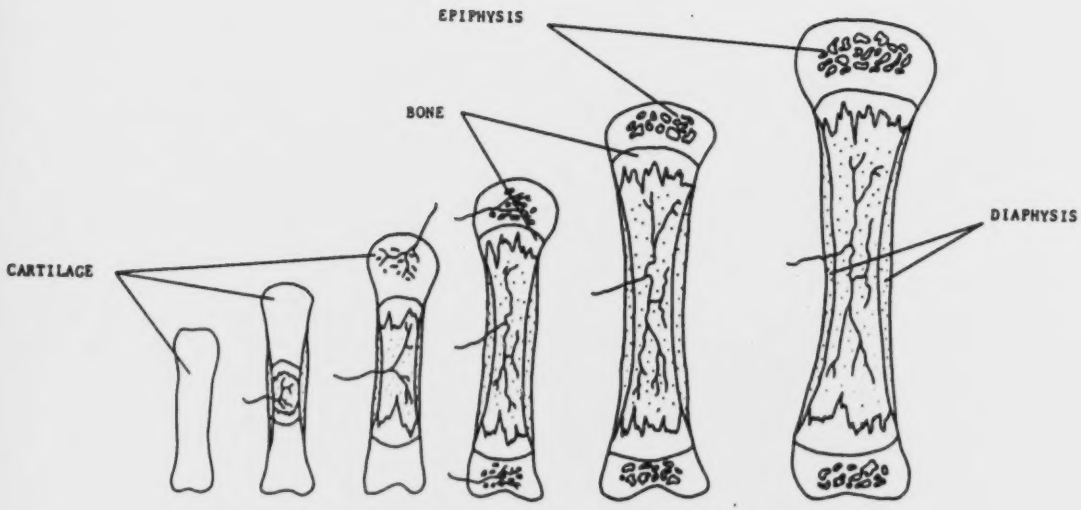

Figure 12 Stages in the Ossification of a long bone

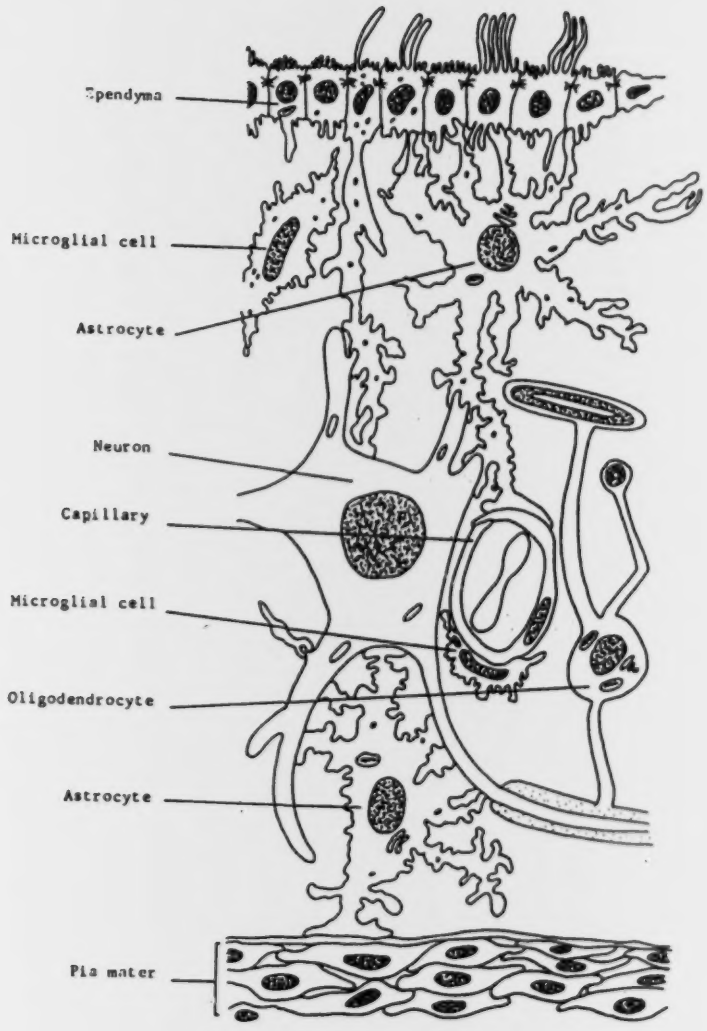

Figure 13. The four types of Neuroglia

Myelin is a fatty substance that wraps the axons of many neurons. It functions as an electric insulator allowing a faster conduction of electric signals (action potentials) along the axons. The thicker the myelin sheath the more rapid the conduction of these action potentials (Nash, 1970). The myelin sheath is formed gradually, beginning during intrauterine life and continuing for several years after birth. The maturation of the nervous system as a whole is closely related to the degree of myelination. Until recently, it was thought that human beings were born with the full compliment of nervous cells required throughout their lives. Recent studies cited by Brandt (1978) and Carter (1980) and reviewed by Brasel and Gruen (1978) suggest that growth in nervous cell numbers occurs after birth. Brasel and Gruen (1978) sum up their review by saying that:

1. "most neuronal cell division, at least in the cerebrum, occurs prenatally ..."[1];

2. "glial cell division is largely a postnatal event with peak replication at three months of age ...";

3. "growth in DNA[2] in the whole brain and its two major regions continues into the second year of postnatal life".

The assembly of the nervous cells in human beings leads to the formation of the brain, the spinal cord and the nerves which extend from the two former components of this system. Usually the brain and the spinal cord are referred to as the central nervous system and the complex of nerves as the peripheral nervous system. However, these are not two independent systems; the peripheral nervous system can be understood as an outgrowth of the brain and the spinal cord. Nerves, spinal cord and brain are interconnected and interact throughout an individual's life.

When a baby is born the nervous system is practially complete with the exception of the cerebral cortex (the outer portion of the cerebral hemispheres). As the child grows older the cerebral hemispheres develop and gradually mature. During this development period several factors are involved, ranging from information contained in the individual's genes to the balance between the infants internal environment and the conditions available in the external (physical and social) environment.

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(1) Note, that here, the possibility of growth in number of neurons after birth is not discarded.

(2) The growth of DNA here means that there is an increase in the number of cells because the amount of DNA in any species is constant per diploid nucleus; further more, the increase in DNA amount in the early stages of postnatal life in tissues which are not able to self-renew reflects an increase in cell number - i.e., reproduction of cells.

There have been several theories put forward concerning this period of maturation. One of these theories is Bronson's (1965) model, reported by Nash (1970). According to this model the three main parts of the brain - brainstem, subcortical brainstem (diencephalon), and the neurocortex (cerebral cortex) - are interconnected by a network of neurons and interact so influencing each other's activities. Figure 14 shows the characteristics of the levels of these networks and their interactions.

The structural organisation of the maturing human brain is, to a large extent, genetically determined. This is supported by evidence of children born without the neocortex (anencephalis) who show, in the first month, similar behaviour to that of normal newborns (Jung and Hassler, referred to by Nash, 1970 and Luciano et al., 1978). This similarity is presumably explained by the immaturity of the neocortex in the first month after birth. At this time a baby's behaviour is co-ordinated by subcortical structures (Conel, referred to by Nash, 1970; Luciano et al., 1978).

The maturation of the cerebral cortex seems to begin between the second and third months after birth. At this time the newborn starts to give more varied, although still undifferentiated, emotional responses. The level-two networks are very important in this change. At this stage the newborn has also changed from the long sleep periods to longer periods of daytime wakefulness. As the neocortex matures the mechanisms such as hunger, intensive stimulation and pain, mediated at level-one are substituted, presumably, by novelty in the environment initiated at the level-three stage.

Certain regions of the brain co-ordinate particular functions and psychological processes, to a great extent, are related to these functions (Nash, 1970). However, the maturing brain is sensitive to physical and social conditions in the external environment. Up to now debate is still going on between scientists who advocate the 'genetic predominance' and those who defend the predominance of environmental influences on psychological development, mainly in relation to intelligence (Halsey, 1977).

Several theories[1] concerning personal development have been constructed, covering aspects such as cognition, emotion and motivation, and integration of personal needs and abilities to social demands. Well known examples of these theories are

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(1) All the theories referred to have been constructed within certain limits - such as, they were built or tested on the basis of a number of observations of some subjects, in a specific place and during a period of time. Therefore, they are all bound to be based in terms of: the observer's background and interest in the study; the subject's genetic endowment, previous experiences, socio-cultural background and natural environment; and, the conditions within which the studies were carried out. A consideration of these limits is well worthwhile when studying these theories.

Levels of networks	Parts of the brain involved	Function	Mechanisms to which the network level responds	Interactions with other level (examples)
1	Brainstem (ancient brain)	Co-ordination of gross bodily movement; innate reflexes (sucking, rooting, pupillary reflexes); orientation reactions (turning of head and eyes); defensive reactions (response to pain).	Internal chemical conditions (blood sugar level, sex hormones); sensory stimul stimulation (visual, tactile); limited capacity for discrimination of sensory input.	Brings levels 2 and 3 to more generalized alertness in response to danger (by narrowing the attentional focus). Inhibitted by levels 2 and 3 with maturation.
2	Subcortical brainstem (diencephalon) thalamus hypothalamus lymbic system	Arousal of motivation and emotions: support of purposive behaviour; refinement of sensory and motor activity	Internal chemical changes (sex hormones); input from pain, sexual stimuli, auditory and visual perceptions.	Refines sensory discrimination and motor co-ordination of level 1. Mediated by level 3 in auditory and visual perceptions and control. Controled by level 3 in excitation.
3	Neocortex (cerebral cortex)	Mediation of perception to maintain the activating systems responsive; fear orientation.	Novelty in the environment; complex stimuli patterns; activity of lower levels; (probably) "higher motives" and individual goals.	Inhibits innate reflexes of level 1. Alerted by level 1 in awareness of the environment.

Source: description of Bronson's model by Nash (1970)

Figure 14 Bronson's model of brain organization and its implications to early development

those of Piaget (cognitive), Freud (psychoanalytic) and Erickson (psychosocial) respectively. A brief outline of these theories is given in Figure 15. Other theories which focus on the influences of the environment upon individual development have been constructed as well - of these, two, the cross-cultural and the behaviour modification theories are perhaps the best known.

The onset of puberty sees the maturation of the sexual organs which has been very slow during infancy and childhood speed up. This is caused by an increase in the production of a group of hormones called gonadotrophins. These hormones are produced by the anterior lobe of the pituitary gland. The production of these gonadotrophins is stimulated by the secretion of another group of hormones or releasing factors produced in the hypothalamus. As yet, the mechanism initiating this secretion is unknown.

The gonadotrophic hormones - FSH (folliclle stimulating hormone) and LH (luteinizing hormone) - are those which activate the maturation of the gonads and, as a consequence, the production of sex hormones. In the female the ovary produces oestrogen and this triggers off the growth of internal secual structures and the development of secondary sexual characteristics. The first menstrual bleeding (menarche) takes place, and from then on the menstrual cycles cycles are established, as shown in Figure 16.

In the male the rise of FSH levels stimulates the maturation of the testes; the seminiferous tubles enlarge, the germinal cells develop and spermatozoa are produced. The secretion of LH leads to the multiplication and maturation of the testes interstitial cells (Leydig cells, placed in the spaces between the seminiferous tubules). These cells produce testosterone, the hormone that activates the growth of the sexual structures and secondary sexual characteristics (Figure 17).

In both sexes androgens are produced by the adrenal glands (placed just above the kidneys and also called suprarenal glands). These hormones contribute to a rapid increase in growth rate and to the growth of axillary and pubic hair. In the male the role of the adrenal and rogens is to supplement the androgens produced by the testes, whilst in the female they have sole responsibility for the above mentioned growth.

The mechanisms which influence the timing of puberty are still poorly understood. However, some factors are seen as being heavily involved in the onset and course of puberty. These factors are the genetic potential of the individual, his nutritional and general health states and the environment[1] in which the individual develops. Recently a hypothesis stating that menarche and other pubertal

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(1) Grumbach (1978) points out geography, altitude and light reception as some of these factors.

(Approximate)	Cognitive Theory	Psychoanalytic Theory	Psychosocial Theory
0 - 18 months	Sensorimotor intelligence	Oral stage	Trust versus mistruct
18 months - 4 years	Preoperational intelligence	Anal stage	Autonomy versus shame and doubt
5 - 7	"	Phallic stage	Initiative versus guilt
8 - 11	Concrete operational intelligence	Latency	Industry versus inferiority
12 - 18	Formal operational intelligence	Genital stage	Group identity versus alienation
18 - 22	"	"	Personal identity versus role diffusion
23 - 30	"	"	Intimacy versus isolation
30 - 50	"	"	Generativity versus stagnation
51 -	"	"	Integrity versus despair

Figure 15 Comparison of the Stages of Cognitive, Psychoanalytic and Psychosocial Theories
(Reprinted from Newman and Newman, 1978)

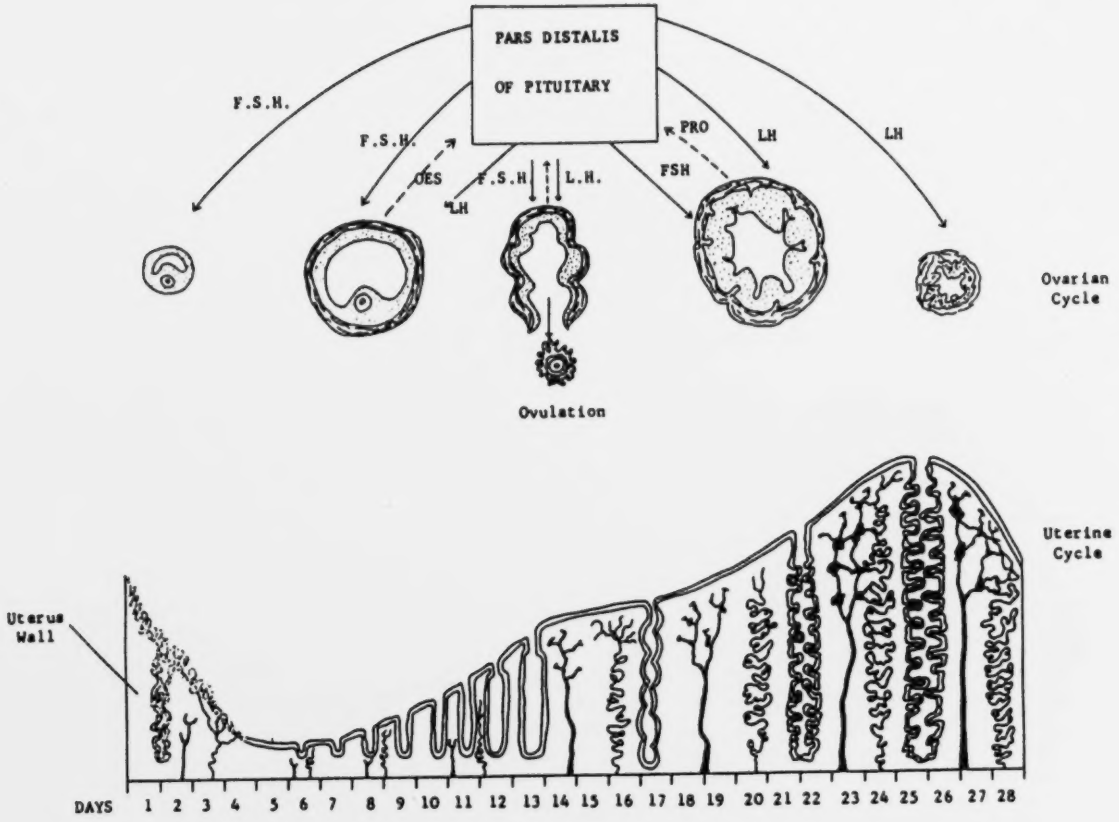

Figure 16 The Menstrual Cycle

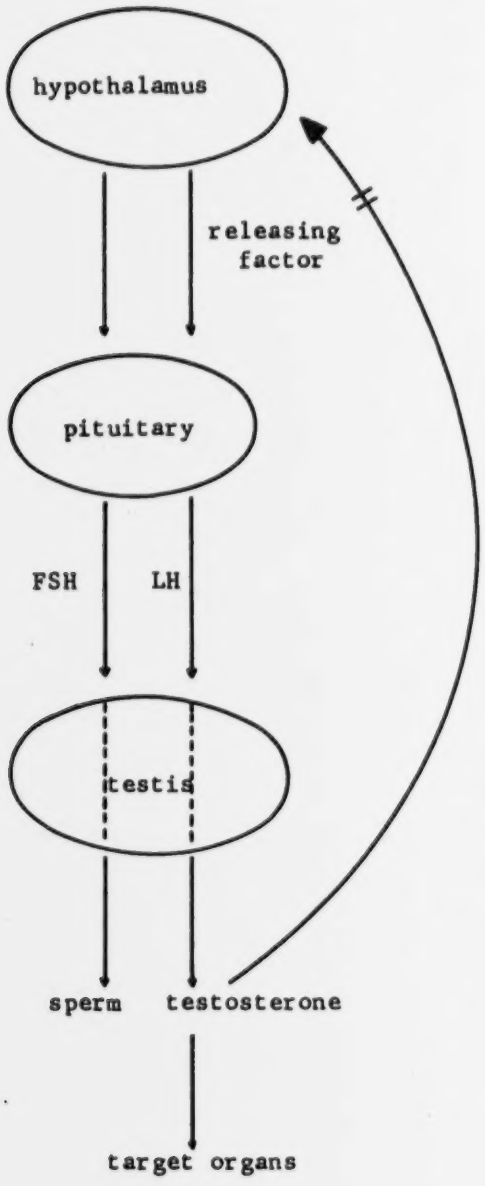

Figure 17 Hypothalamic Control of Sperm Production and Testosterone Synthesis

aspects are related to a certain percentage of body fat has been put forward by Frisch (1976). A mean weight of 48kg. (7 stones 12lbs.) was found to be correlated with the onset of menarche. Some findings seem to support this hypothesis, such as: delayed onset of menarche in states of malnutrition and ill-health; changes in gonadotrophin secretion and amenorrhea[1] in cases of anorexia nervosa; and, earlier age of menarche in moderately obese girls (Firsch, 1976 and Zacharias et al., 1976, referred to by Grumbach, 1978). However, some researchers (cited by Grumbach, 1978) view these relationships as being somewhat speculative and controversial.

Studies carried out on data based on the last hundred years in a number of western European countries and United States, indicate that the difference in the age of menarche between these countries is reducing and show a general trend towards earlier menarche. (Figure 18). Clegg (1968) offers some explanations for this trend[2], namely: gradual improvement in the standards of living, including nutrition; and increased interbreeding due to the effects of better communication and transport on the mobility of populations.

As far as males are concerned there is generally a lack of data (apart from a study in Istanbul and one in Israel cited by Marshall (1978)) concerning the onset of sexual maturity. The onset of ejaculation is usually seen as the indicator of sexual maturity, and as Kastenbaum (1979) points out, this is more difficult to determine than the onset and subsequent rythum of menstruation and so the lack of data is not surprising.

Besides the physical and cognitive aspects of development discussed above, human development to adulthood involves profound emotional changes (Carter, 1980). Carter relates these changes in many societies to three main factors: the breaking away from physical and emotional dependence on the family; close emotional links to a peer group; and, the adjustment to personal sexuality. Kastenbaum (1979) has argued that these are not simply phenomena related to the so-called adolescent stage, but are rooted in earlier years of life. It should also be noted that these features seem to manifest themselves differently in different socio-cultural environments. Opler (1971) suggests that pre-literate societies seem to do better at integating adolescents into work and social activities than more technologically advanced societies, where youth culture has become a characteristic phenomenon.

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(1) Absence or suspension of menstruation.

(2) Clegg's explanations are based on data published in 1962 by the same author referred to by Marshall (1978).

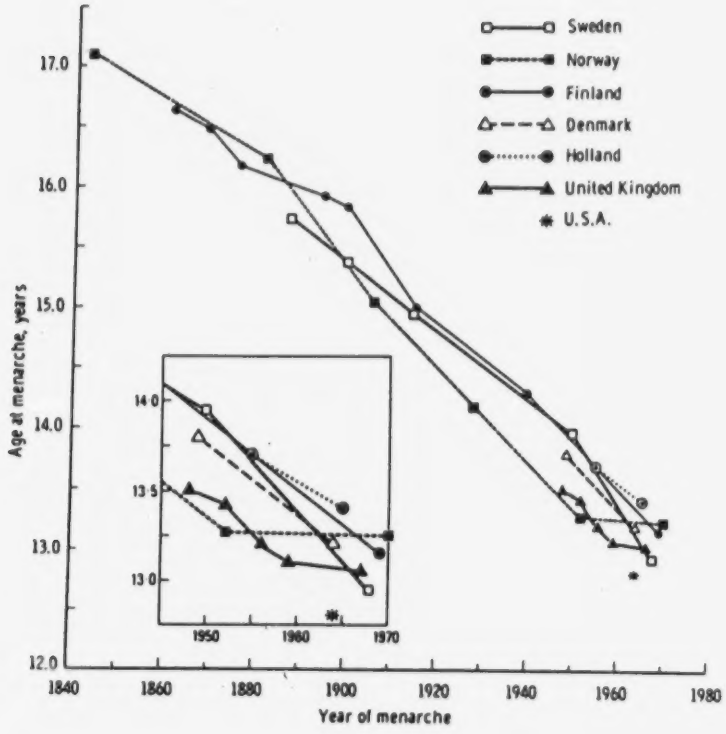


Figure 18 Change in Age of Menarche 1840 - 1970
(Redrawn from Falliner and Tanner, 1978)

The course of individual experiences during earlier stages of life guides the orientation that one takes in adult life. The turning point from adolescent to adult is difficult to identify, although it is normally related to the involvement of the individual in a number of societal roles. Probably the undertaking of these roles is a vital factor in the reaching of a personal identity, which is one of the components of the uniqueness of the human individual, resultant of the interactions between the genotype and the environment, expressed by the phenotype. However, human individuals share a great deal of similarities, therefore they can be looked at from another perspective: as a species. From this perspective individual uniqueness is subsumed into a much broader concept - that of variation within the species, as discussed in the following Chapter.

CHAPTER 3

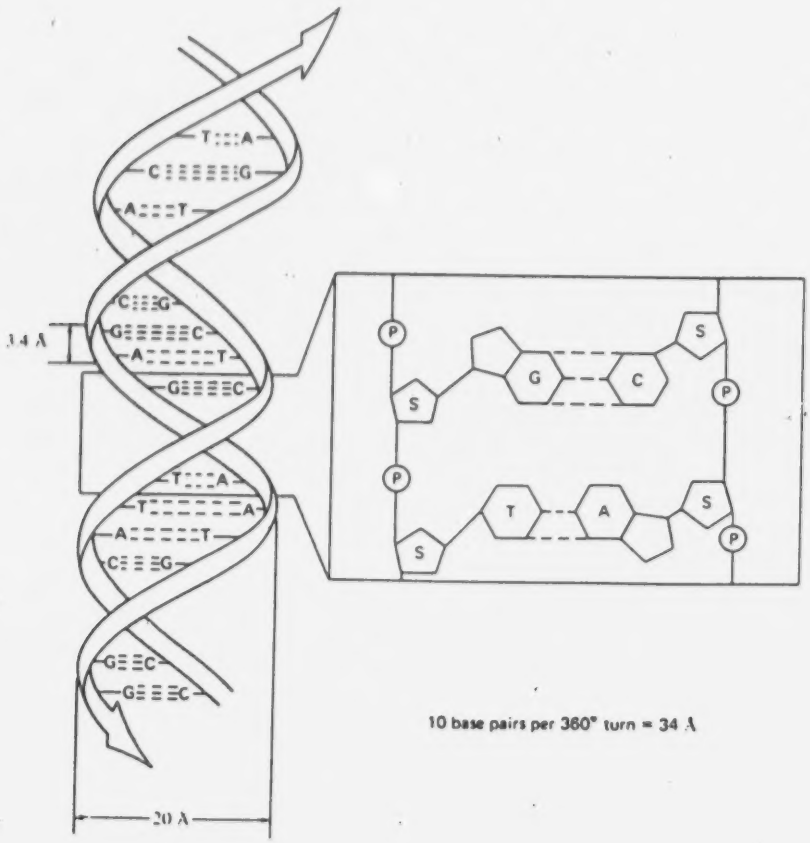
VARIATION, EVOLUTION AND GROWTH IN HUMAN POPULATION

The differences in external features of people living in the various parts of the world are very obvious: the colour of the skin, the distribution and texture of body hair, the facial characteristics and the head form are some of the most obvious differences. These are dut to physical traits genetically transmissible (Stine, 1977). In this way the human species is an aggregate of smaller groups of people who share a number of inherited features which distinguish them from other similar groups. The smaller groups which form the human species are the human subspecies or races.

The genetic information in humans is contained in the twenty three pairs of chromosomes, in units called genes. These units are formed by a complex chemical substance - the DNA (deoxyribonucleic acid). The molecules of DNA encode the information necessary for the specification of all the genetic traits. It is the interaction of these units (the genotype) with the external environment that determines the course of an individuals development and leads to the existance of the range of human subspecies mentioned above. The genes located in homologous chromosomes can exchange and recombine with each other during the process of gamete formation (gametogenesis). This happens due to two processes: crossing-over - i.e. the exchange of segments of homologous chromosomes; and, translocation - i.e. the shift of a chromosome segment to another area of the same chromosome or to a different chromosome. This process of re-combination alone can be responsible for an innumerable variation in the human species. Two other processes can also increase the probability of this variation: the assortment of chromosomes from a diploid cell and the change of genetic information)mutation) in germinal cells.

The genotype of an individual is modified only if a change takes place in the genes. When this change is not caused by segregation or recombination and alters the structure of the gene or, more specifically, the DNA molecules, it is called mutation. The process of mutation is probably very old, the DNA molecules having a structure that favours a wide scope of change, although these molecules are usually very stable. The DNA molecule is formed by a combination of small units called nucleotides. Each nucleotide, in turn, is composed of three types of substances: a nitrogenous base, a sugar and a phosphate. The two later substances are always the same in any nucleotide but the nitrogenous bases are different. There are four types of these bases: adenine (A), thymine (T), cytosine (C) and guanine (G). Therefore there are four possible

kinds of nucleotides forming the DNA molecules: A, T, C, G. These nucleotides arrange themselves into a double helix molecule, as shown in Figure 19. The sugar (S) and the phosphate (P) molecules alternate along each thread (strand) of the helix, and the different bases, joining in pairs, link the two threads. The pairs of bases are always the same - A joined to T and C to G. For example, if one strand of DNA is A G T C, the other will be T C A G (as seen in the upper part of Figure 21). This pairing is crucial for the determination of a species. It is the sequence and the number of the nitrogenous bases in the molecules of DNA that provides the genetic code which ensures the exclusiveness of a particular species. Human characteristics are coded in this way and all normal human beings have a certain sequence and number of nucleotides in their DNA molecules.



the chemical nature of genetic material

Figure 19. Base Pairing and Polarity. Molecules of DNA showing opposite polarity (indicated by the direction of the arrows) of the double-stranded spiral helix. Physical measurements in Ångstrom units (10^8 Å = 1 cm). (Redrawn from Stine (1977).

The pairing of bases is essential for the replication of the DNA molecules. For example, a molecule of DNA with the sequence $\frac{A\ T\ C\ G\ G\ T}{T\ A\ G\ C\ C\ A}$ is broken down into two strands. Each strand serves as a template (pattern) for the formation of two new DNA molecules, each identical in sequence to the original. If, during the process of replication, a nucleotide is replaced by a different one (e.g. adenine is substituted by cytosine), then one of the two new molecules will have a different sequence to the original (e.g. $\frac{C\ T\ C\ G\ G\ T}{G\ A\ G\ C\ C\ A}$). This kind of change directly affects the genetic code of an individual and, consequently, his/her genotype.

The above example of substitution is only one of the possible ways in which a mutation can occur in DNA molecules. Other ways are the addition of an extra pair of nucleotides to the newly formed molecules or the deletion of a pair from the original molecule. These mutations might occur without any environmental factors such as radiation and chemical substances may induce the DNA to mutate. Only when an individual's mutation is transmitted to succeeding generations does it have any significance for the species. In a population there is selection for or against mutant genes. If environmental conditions are favourable for the expression of a mutant gene this new gene is added to the total number of genes (gene pool) within a population. In this way, genetic alterations are maintained within a species by a process of natural selection.

The variations within the human species can also result from a selection of individuals who have a capacity to withstand adverse environmental conditions (stress). Famine, for instance, may cause the death of individuals lacking sufficient fat reserves, whereas those with such reserves stand a better chance of survival. In this way by selecting out certain phenotypes the gene pool of a population is changed.[1] (Campbell, 1974)

Another process that results in variation in a population is the adaptation of the individuals to changes in the environment. In this case only the phenotype of the individual undergoes change in response to environmental stress. Hardesty (1977) presents examples (drawn from Lasker, 1969) of responses to altitude and temperature changes. An individual migrating from sea-level to 12,000 feet has increased breath and pulse rates, followed by an increase in hemoglobin concentration. In the case of individuals who develop at high altitudes another kind of change is seen: they exhibit large lung capacity and slow maturation of the skeleton. These changes are due to the low content of oxygen in the atmosphere in elevated areas. In the first case, the individual adapts to the environment in a reversible way - i.e., the physiological changes are only a result of a process of acclimatization. In the second, the anatomical and physiological changes are irreversable; they are possible because the organism has a capacity to undergo certain limits of change (plasticity).

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(1) Brook (1975) suggests strong genetic effect in the variation of fatness.

It has been suggested (Hardesty 1977) that behavioural change is the most rapid response that an organism can make to cope with the environment. At this moment in time a great deal of controversy still exists over the issue of whether genetic or environmental influences predominate in the establishment and development of behaviour in human beings. This controversy seems likely to persist for some time as recent studies on both sides appear to have only scraped the surface of the issue. For the time being, it seems to be enough to understand that appropriate demands (inputs) from the environment might trigger off genetic potentials within the individual thus initiating the basis for some behaviours. These types of behaviour may change as a result of variation in learning, imagination, consciousness and creativity, hence it can be deemed as intelligent behaviour. The sharing of some behaviours by members of a group over a number of generations leads to the development of cultural behaviour - "the most distinctive feature of the human species" (Hardesty, 1977).

Man is a mammal and, as such, has a number of similarities with other animals of this class. The success of the mammal over the reptile is contributed to by the development of (a) the ability to maintain a constant body temperature and (b) a wide range of behaviours. These two aspects of mammalian evolution are linked to each other in that independence from external temperature enabled these animals to be constantly active and this probably, led to more and more complex behaviour. The maintainance of a constant temperature required a permanent food supply, meaning early mammals could not be dependent on a narrow-range diet. Constant and varied feeding helped the development of mechanisms which allow maximum nourishment from food intake. One of these mechanisms was the change in the form of the jaw and teeth, so as to enhance mastication and favour the action of digestive juices on smaller particles of food. Another important adaptative aspect that helped in the success of mammals was the capacity to keep the fertilized egg within the mother's reproductive system during the early stages of development. This reduces the risks of a high newborn mortality rate. The control of the reproductive functions by hormones led to a regular production of a small number of offspring which can be cared for when young. The presence of the milk glands enhanced germ-free feedings which provide the necessary nutrients and antibodies for the successful development of the offspring. All these characteristics made possible a relatively high rate of evolution, allowing the survival of mammal populations in a wide range of environmental conditions (Campbell, 1974).

One group of mammals, the insectivores, very similar to the modern-day tree shrew, probably adapted to tree-climbing by avoiding competition with other ground-based animals. The tree shrews, the lemurs, the tarsiers and the lorises, forming the group (sub-order) prosimians, probably evolved from the insectivores.

From the arboreal life of these early mammals evolved the new postures and forms of locomotion of the later primates. The modification of the vertebral column into a vertical weight-bearer led to the fully erect posture and to the terrestrial mode of locomotion on two feet (bipedalism). The thorax flattened bringing the centre of gravity over the pelvis; the tail changed, forming the floor of the pelvis and the head became balanced in relation to the neck. The erect posture and bipedalism, in their turn, caused significant changes in the pelvis, hindlimb and foot. The pelvis broadened giving greater leverage to the muscles in charge of forward propulsion and lateral balance; the ilium (one of the pelvic bones) shortened and widened, thus allowing the articulations (sacral and acetabulum) to move closer and give a greater stability in the transmission of body weight. The position of the pelvic-girdle in relation to the spine gave support to the viscera. The hindlimbs straightened, allowing the transmission of body weight from the acetabulum to the ankle through the knee joint. The foot became narrower and was able to sustain the whole weight of the body; this weight being distributed at three points: the heel, the big toe and the small toe.

Another important aspect in the evolution of the primates, and particularly Man, was the evolution of the anterior paws into hands. In all the primates but man the hands assumed locomotor as well as tactile functions. The evolution of the opposable thumb allowed the primates to use the hands not only for grasping, but also for many other purposes, such as carrying objects, procurement of food and use of tools. This ability to manipulate objects was critical in the evolution of visual perception as objects could be detached from the environment and examined in greater detail. This, in turn, is assumed to be one of the fundamental pre-requisites for the development of cultural behaviour. In man the thumb developed in length and in strength as well as in the ability to rotate and to move in two planes (due to a joint at its base). This structure of the hand gave man a precise, strong and yet delicate grip. This grip, combined with the fact that the hands were free from locomotive function, gave man a great advantage over all other primates: that of being able to make tools.

The brain in the primates has increased in size and reaches its maximum volume in relation to body size in man. Some changes in the structure of the head such as the reduction in the size of the facial bones, the position of the eyes and the increase in size and verticality of the forehead favoured this increase in brain size. Associated with this increase have been changes in the structure of the brain. The primitive part of the cortex reduced as the importance of the sense of smell diminshed. In contrast, the neocortex has increased with the development of the sense of sight (occipital lobe) and the visual and auditory memory (temporal lobe). It is the frontal and parietal lobes that have expanded much more in man than in other primates. This expansion is connected with the sensory and motor co-ordination areas, the speech centre and the initiative and attention control area. Campbell (1974) and Roze (1976) suggest that higher mental

processes may have envolved because of man's need as a hunter to work towards an objective with sustained attention and use of some form of communication. The parietal lobes have a well developed association cortex which integrates auditory, visual and somatic sensory input. Part of this association cortex coincides with the major speech area. Besides the integration of signals from different sense organs, there is also evidence that the speech area, found in only one side of the brain integrates with the other correspondent side where there is some evidence of abstraction - elaboration of notions of space and body movements. Two other important features of the human brain are its folding and bilaterality. The larger area of the surface of brain cortex (64%) is hidden in fissures; this is also the largest proportion amongst the primates. This increase in the area of the cortex is mostly significant for the complexity of the functions that the cortex has to perform.

With the development of bilaterality the human brain improved in efficiency - the two hemispheres are not any more just a copy of each other as in other mammals. The functions which do not require spacial duplication are present in only one hemisphere. For example, speech and word memory are apparently functions of the left hemisphere, whilst concepts of proportions, relationships in space and sound are dealt with in the other.

The evolution of the brain to the level of human complexity was gradual and seems to be related to different stages of primate evolution. Brain and behaviour may have evolved in an integrated way, during which environmental stress and natural selection have exerted a great deal of influence. This interaction between brain, behaviour and environment, led to the development of strategies which increased man's chances of survival and continued improvement.

It is assumed that man's ancestors - Ramapithecus moved bipedally; if this is true, most probably they lived near open land, since bipedalism is not an adaptation shown for inhabitants of tropical forests. Probably around fifteen to twenty million years ago (Miocene) the first hominids moved away from the forests, perhaps due to the effect of the rapid climatic changes on the rain forests (Roze, 1976). Australopithecus, a later ancestor of man shows the use of tools, perhaps in hunting. This was a strategy to compensate for the scarcity of vegetable food, helped by bipedalism, capacity to see at great distances, ability to run and using cutting tools. (Campbell, 1974 and Unesco, 1975 and 1977a). To survive in the savannah these hominids, besides defensive co-operative behaviours developed also offensive co-operative ones, such as collective hunting. According to Campbell (1974), with this type of hunting, the dependence between male and female and the support needed by children from both, led to the 'one-man-group', the beginnings of kinship structures. The

movement from water sources and trees into arid savannah involved the more extensive use of tools and a more organized social life. Adaptation to temperate areas led to the need of energy saving and maintenance of body temperature, helping the development of strategies such as sheltering and clothing. The cold winters, limiting man to move about and to find enough supplies of food, may have resulted in the use of containers and development of storage techniques. Meat supplemented a vegetable diet but during late winter and early spring probably became the main food source. Efficient techniques for hunting large animals to feed larger groups were achieved. Hunting populations were sparse, therefore gene flow and cultural transmission was restricted. Moving further north, facing colder temperatures, man developed a more sophisticated socio-cultural organization. Division of labour and sex-differentiation started. Man became the hunter and women gathered vegetable food, cared for the offspring and collected water and fuel. At later stages, the trapping of migratory herds probably led to a more sedentary life, domestication of animals and farming - all adaptations that proved to be efficient in terms of converting natural energy into food.

The efficiency of the above adaptations permitted the development of settlements; these, in turn, reduced competition and increased co-operation. Food-sharing, marriage, kinship, exogamy, broadened the social group interaction. Improvement in farming techniques by the use of more productive technologies, bound man to territorial and economic organization and deepened the dependence on framing. More organized social groups such as tribes and chiefdoms replaced the hunter-gatherer bands (Wilson, 1975).

Social groups also made possible a more extended transmission of learned behaviours among its members. Although early man was able to learn from observation, imitation and trial and error, learning by instruction was favoured by the evolution of language. Both, instruction and language, widened communication and facilitated transmission of culture. With this transmission human populations improved the ways to overcome natural selection and other selective pressures. Man became able to survive environmental changes by making appropriate technical adjustments. According to Ingold (1979) each transformation in the environment "marks a phase in a determinate process of social evolution whilst within each phase there will be a trend of cultural adaptation".

Cultural and social evolution, having minimising effects of some natural hazards and making possible changes in the environment to meet man's demands could have allowed for a fast increase in the size of human population since earlier ages. However, this increase has been at a slower rate than one might assume to be the case. In fact, only three population explosions have taken place in the history of man, as shown in Figure 20.

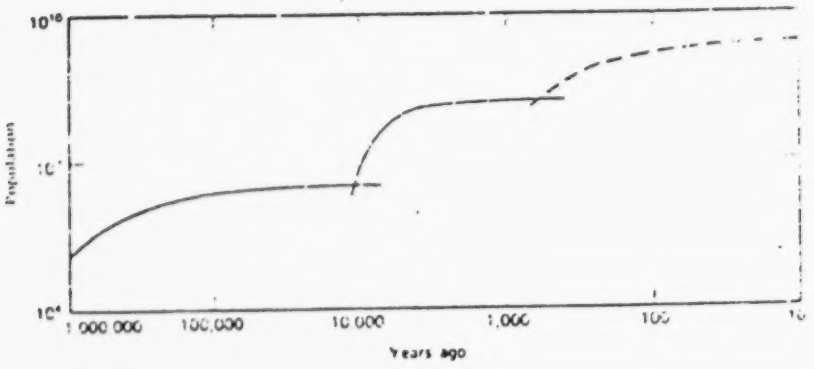

Figure 20 The history of human population growth. (From Edward S. Deevey, Jr., "The Human Population.") (Reprinted from Hardesty, 1977)

The first population explosion is related to the invention of tools; the second with the development of farming and the last one with the Industrial Revolution. These explosions suggest that man's success has been dependent on the interaction between culture and environment, and mainly on the development of technology. Taking the case of the second explosion, some relationships between the development of farming and the increase of population size can bring out the above mentioned dependence. Studies reviewed by Jochim (1981) show that hunter-gatherer populations have to move camp very frequently due to a main factor: the availability of food supply. This main factor is added by other such as climatic conditions (e.g. heavy rains), rubbish accumulation, epidemics, revalidation of personal relationships. Due to the frequency and distance that the population have to travel the increase of population is restricted (Lee, referred to Hardesty, 1977). This is explained by the fact that women in these populations have to handle the children and carry very heavy loads whilst moving. Therefore, the more children a woman has, the more restricted

limits are placed on their movement and consequently, of the whole group. Lee (reported by Hardesty, 1977) studying the case of the 'Kung Bushman of the Kalahari Desert', show that while being nomadic, the birth intervals in these populations were around four years per woman. This length of time between births was kept by an extended breast feeding practice (which, usually supresses ovulation), which was also related to the innadequacy of a wild food diet, difficult to be digested by the children before they are three or four years old. Other cultural practices for population control were also used by these populations, such as infanticide. In recent years some of these groups have become more sedentary, adopting some farming techniques, such as the plantation of maize and melons and the domestication of goats. The work load of the woman has decreased with the reduction of movement, and the average birth interval per woman has shortened to three years or slightly less.

The settlement of populations in more permanent basis is seen as a "strategy for attaining, economic, social and political ends" (Jochim, 1981). Farming tends to concentrate people and resources in space and intensive farming techniques can support larger populations in smaller areas. In this way, agriculture favoured the increase of population in restricted areas (nucleation), for several reasons: man became less dependent on environmental hazards; resources can be concentrated and the land is used in more efficient ways; larger populations can be supported by means of economic diversification and interactions such as sharing and exchange; interpersonal contacts are intensified, institutions are developed and the transmission of culture is facilitated.

According to Netting (referred to by Jochim, 1981), farming populations show different relationships, depending on the availability of land. When land is abundant and there is possibility to adjust it to the population's needs and demands, a flexible organization develops: social relationships facilitate residential mobility to cope with environmental conditions and economic difficulties. When land becomes scarce, intensive agriculture reduces mobility and strengthens the association of people to plots of land. Access to land and redistribution of people becomes limited, stress and insecurity develop and means to deal with them have to be found. One of the survival strategies in the case of scarcity of land is the organization of groups according to kinship. Rules are established to guarantee trust and productivity amongst the members. In contexts where intensive labour is needed, such as in 'slash-and-burn' agriculture, it is common to find extended families as the group unit. Other forms of organization have also been developed in such a situation. These include lineage organization (from ancestor to descent), patron-client relationships, hired-labour, and slavery. All these forms are interpreted as cultural responses to problems encountered in the environment which demand high labour to maintain a state of balance between man and environment.

The survival of a population depends upon a minimum balance between availability of resources and demands upon them. The basic natural processes of birth, death, climatic changes and geological catastrophes play a vital role on the growth of a population, but other processes, selected in the course of cultural evoluation interfere a great deal on population growth. These cultural processes allow for compensation for problems which are potential threats to a population, such as competitive and conflicting group demands. In this way, strategies were selected to minimise the effects of shortage of resources (due to natural causes such as droughts, floods) or stresses caused by lack of flexibility and diversity in a group's structure. Among these strategies, the following ones are common to many populations:

(a) the demarcation of territorial boundaries, such as the creation of an empty strip of wasteland between groups, as found in the Kofyar tribes in northestern Nigeria and, the use of ecozones (zone of transition between two ecological communities), as found among the Chippewa and Sioux indians in Minnesota (Jochim, 1981).

(b) the prevention of loss, wastage or misuse of resources, such as the diversification of planted crops according to the type of soil, as Johnson (1974, referred to by Hardesty, 1977) reports on planting practices among Brazilian sharecroppers.

(c) the storage of resources to cope with seasonal changes and to use land, time and labour in more efficient ways; here techniques of freezing, smoking, stockpiling and drying food, well spread all over the world are some examples.

(d) the development of exchange networks with other groups, e.g. festival exchanges practiced among the Chimbu Tribes in New Guinea (Brown, 1979).

(e) redistribution of resources, such as in trade or raids, Harris (1979) reports on a long distance trade network between the islands and the mainland populations of Torres Straight, where products exclusive of the islands or of the mainland were regularly exchanged and systematically traded according to their socio-economic importance and rarity.

(f) redistribution of people, such as migration of large numbers of people from one community to another for a number of reasons. Marshall (1982) in a study on migrations and change of ecossystems in the Caribean islands, shows a number of factors such as expansion of sugar cane plantations; payment of better salaries; change of policies and technological development interferring in the movement of people from one island to the others and even to America and Europe.

Overpopulation, a result of population growth beyond the availability of resources in the environment, and which cannot be compensated for by the use of cultural mechanisms, is a risk to the survival of mankind. In this way, strategies have also to be developed to regulate population growth and balance within certain limits. The occurrence of overpopulation can be related to a number of causes, such as the increase of a population in size or in demands; the excessive requirement of work effort from its members; or the falling of productivity in relation to needs and demands. The latter two causes can be dealt with by the development of new technologies; expansion of productive activities and the development of socio-political networks, such as preservation, sharing and distribution of resources (Jochim, 1981). However, the first cause of overpopulation requires the limitation of the size and demands.

The regulation of population size involves two biological processes: the reduction of birth rates and the increase of mortality rates, as well as several cultural processes. The reduction of birth rates is directly dependent on the fertility of the female members of a population. Natural processes, normally regulate the reproductive capacity of a human population; the length of the menstrual cycle, the supression of ovulation during lactancy, and the age of menarche and menopause. Natural changes in the environment, such as shortage of food, and/or its poor nutritional value and possible epidemics leading to ill-health, cause fertility rates to decrease.

Cultural strategies for limiting birth rates are varied and have been in operation for a long time. Some of them are straightforward and involve no personal risk to the women (sexual abstinence and sexual segregation); others, are more complex and may affect the health of a female, but are relatively reliable control techniques (contraception and abortion). Others, are yet more sophisticated, involving long processes and intervention of institutions, such as religious committments (e.g. celibacy), education (e.g. optional family size) and legislation (e.g. limits defined for marriage in monogamous societies).

Mortality rates, like birth rates, vary from population to population and are also dependent on natural as well as socio-cultural processes. Among the natural processes there are: 'old age', epidemics, (droughts, floods, snow blizzards), geological phenomean (earthquakes, vulcanic eruption). Socio-cultural processes can involve warfare, ritual sacrifices, infanticide, senilicide, invalidicide and genocide.

CHAPTER 4

CURRICULUM MAP

This chapter is the first of three chapters which are presented as a case study in order to facilitate the organisation of the information and to provide a more realistic picture of the teaching of human biology in a third world country. It is anticipated that in many of the countries which are going to receive this book, the teachers are still facing the problem of lack/shortage of teaching resources. Manufactured audio-visual aids and laboratory materials are difficult to obtain for many schools. Thus, it has been assumed that the suggestions presented here should be applicable to those schools which have no laboratory or other sophisticated teaching materials. These suggestions are then based on the situation of the teaching of human biology in Brazil, particularly in the State of Bahia, where the teachers have to rely on materials that they can build up - by themselves or with the pupils' help. However, an attempt will be made to introduce content, approaches and activities which may help teachers to escape from the mere use of "blackboard, chalk and talk".

The teaching of human biology in secondary schools in Brazil is restricted to a year at the lower level of secondary education[1] (usually grade 7 or 8), and as a part of or integrated into a general biology course at the upper level (usually in the 1st form). The majority of the syllabuses in operation in the schools indicate a very traditional approach to the study of this subject. The human body is presented as a structure, with little emphasis on its physiology. Each system is dealt with separately; little attention being given to integration among systems and even less to the interactions between the organism and the environment. Textbooks, also, follow a similar approach. In this way, it has been difficult for the biology/science teachers to develop course plans which help the pupils to acquire a more holistic perspective of human biology.

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(1) In the present structure of the Brazilian school system the major levels are "1º grau" (from 7 to 14 years old pupils) and "2º grau" (from 15 to 18 years old pupils). The "1º grau" is formed by three levels (I, corresponding to the former primary school - age range 7 - 10; II and III corresponding to the former lower secondary level - age range 11 - 14). The "2º grau", former upper secondary level, is organised into a first year - general education subjects - and second and third years, vocational education, in the majority of the state schools.

The map that follows presents, first of all, educational outcomes which can be achieved through the study of the biological principles which are then specified. Topics and their respective conceptual structures derived from biological principles are also presented. The sources for this curriculum map are the syllabus and programmes above mentioned and the review of the literature on Human Biology in Part I of this book.

Throughout three views are emphasised. First, that of development as a continuous process, dependent on the interactions between the genotype and the environment. This view gradually leads into the second: that of the diversity within a species as a contemporary, collective expression of the above mentioned interactions. Third, and closely related to the former ones, that of evolution as a process as well as product of the transformations resultant from those interactions through time.

The curriculum map is organised into two sections. The first deals with development as a complex of phenomena that occurs at the level of the individuals. The second concerns phenomena that occur at the level of the species - variation, evolution and population growth.

Section I.1 The development of the human individual

Educational Outcome	Biological Principle
Awareness of the process of development as a continuous sequence of changes which the human organism undergoes from birth to death.	Living beings develop from simple to more complex states.
Understanding of the interdependence between the individual genetic endowment and the conditions offered by the environment for the development of human beings.	The genotype of an individual determines the range within which its characteristics can develop.
Appreciation for the built-in potential survival mechanisms of living systems and the ways in which they come to operate as a consequence of the interaction between internal and external conditions.	Individuals can tolerate a certain degree of change in their internal balance as well in their external environment.

Educational Outcome	Biological Principle
Awareness of the significance of socio-cultural and economic conditions in the development of human individuals.	Individuals undergo a certain degree of change in their internal balance when external conditions change.
Awareness of the responsibility of individuals for the provision of favourable and society conditions for human development.	The influence of environmental conditions on the expression of genetic traits and the process of development as a whole.
Appreciation of ways in which scientific and technological knowledge can help promote healthy development in human beings.	Man can bring about changes both in the environment and internal balance of individuals as a result of cultural and socio-economics development.

Topic	Conceptual Structure
<u>Intrauterine development</u>	Gametes Genes . recombination . interaction
Fertilization	Zygote Cleavage Morula
Embryo formation	Implantation . blastocyst . trophoblast . embryoblast
Embryo development	Germinal layers Embryo membranes and placenta - roles . nutrition . protection . excretion

Topic	Conceptual Structure
	Development of the organs and systems - sexual structures - nervous system - muscles - skin and sense organs - heart and vessels Action patterns - reflexes - body movements - reactions to sensory-stimulation
Interactions mother - baby in pregnancy	Mother's body changes - uterus - breasts - overall weight . increase in metabolism
Mother's states influencing foetal development	Age Nutrition Health/genetic abnormalities Habits and vices . smoking . alcohol . drugs Psychological balance
Consequences of mother's state on foetal	Heart beats, Breath rates } alterations Absormalities: genetic, congential, mental, physical Diseases Low birth weight
External environment influences on mother and foetal	Poor diet - low birth weight - high risks of . mortality . motor and mental impairment Stress - hormonal changes - excitation

Topic	Conceptual Structure
	Family attitudes - positive: favours the foetus development - negative: risks of ill-health. Epidemics and communicable diseases - rubella; defective diseases - tuberculosis) low - malaria) birth - syphlis) weight
<u>After birth adjustments</u>	Interruption of placental exchanges - first breath - control of body termperature) brown - energy production) fat - active circulation - high level haemoglobin in) bilirubin blood stream excretion - enzyme deficiency High level of stimulation in external environment . activation of sense organs
<u>Development in lactancy and infanthood</u>	Breast feeding - easy digestion - germ free - balanced composition - antibodies - direct contact mother-child - affective links mother-child Formula - milk feeding - difficulty of digestion and absorption - high concentration of . fat . minerals - possibilities of contamination - possibilities of errors in dilution . consequences on: plasma balance; kidneys.

Topic	Conceptual Structure
	Solid feeding - difficulty of digestion and absorption of pieces of food . increased efficiency: mashed) food finely chopped) - rapid gut transit . waste of energy from ingested food - susceptibility to gastro-intestinal infections . indiscriminate eating . contaminated food . immaturity of defence systems . lack of hygiene in food preparation
Systems of nutrition maturation	Baby's nutrition systems state - efficiency in digestion and absorption . protein . sugars - inefficiency in digestion and absorption . fat: inadequate production: . bile . lipase - immaturity of kidneys for regulation . surplus minerals . surplus proteins - consequences . plasma high concentrations . oedemas (sodium) . water loss x intake . danger of dehydration . tetania and fits (calcium x phosphate balance) Maturation of the systems - increase in number and amount of enzymes produced - increase in efficiency . absorption . excretion

Topic	Conceptual Structure
	- establishment of rythms - metabolic efficiency Energy requirement - high cellular metabolism - large consumption . brain development . high rate of cell reproduction . building up of muscles and bones . body temperature balance: skeletal muscles production of heat; heat loss: . large body surface area.
Nervous system maturation	Nervous cells replication and growth. Myelination Development of cerebral hemispheres - maturation of cerebral cortex . gradual actions co-ordination . development of sensori-motor patterns . sleep-awakeness cycle . innate reflexes . emmotional reactions . first habits . language development . relating means and goals . insights . discovering new means
Genetic and environmental influences on sensorimotor stage	- adaptation of previous patterns into new ones . exploration of the environment . personal contacts . manipulation of objects (toys)

Topic	Conceptual Structure
	- diet influences on nervous system and cognitive development . undernutrition consequences on: protein synthesis; brain development.
Muscular and skeletal systems growth	Integration muscles-bones-nervous co-ordination Muscles - fibres replication after birth - motor development . elasticity . strength . co-ordination - growth . hormones influence . physical activity Baby's bone constitution - cartilage - bone . ossification processes: epiphysis cells; intracellular substance. Bone growth . articular cartilage . cartilaginous disc . shaft periosteum.
Environmental influences on muscles and bone development	Nutritional demands . protein . minerals . vitamins. Consequences of the lack . protein and calcium failure of proper ossification . vitamin D rickets Sun rays importance for vitamin D synthesis. Physical activity for muscles and bones growth.

Topic	Conceptual Structure
Development in childhood	
Continuous readjustments between body parts and systems	Physical growth - muscle and bones - redefinition of proportions . head . trunk . limbs - increase in size of organs and structures of different systems.
Hormonal regulation of growth	Endocrine system interaction in growth and development Pineal body and thymus gland - development - roles . immunological (thymus) . control of sexual glands . stimulation of physical growth - disfunctions Thyroid gland - roles . regulation: physical growth; body metabolism. - disfunctions . low activity: cretinism. . high activity: Basedow syndrome. Parathroid gland - role . regulation of metabolism: calcium; phosphate. - disfunctions . low activity: fits; tetania. . high activity: failure of bone mineralisation.

Topic	Conceptual Structure
	Pituitary gland (hypophisis) - role in development . secretion of growth hormones: activation of growth; regulation of the rate of bone growth. . activation of thyroid (secretion of thyrotrofic hormone) - co-ordination of other glands - disfunctions . high activity: gigantism; acromegaly. . low activity: dwarfism.
Nervous system maturation and cognitive development	Cerebelum development . weight increase . co-ordination of fine and articulated movements . integration of sensory functions. Brain growth and maturation . weight increase . function differentiation in the cerebral cortex - cognitive development . preoperational stage: production of signs and symbols; independente thinking; retrieval of actions: . symbolic play . symbolic drawings language use. . operational stage: concrete reasoning; systematic, consistent thinking; relating thoughts; replacement of concrete reasoning for conceptual structures; integration of thoughts into complex systems.

Topic	Conceptual Structure
Environmental influences in childhood development	Availability of food - Poor diets . protein: brain development (early stages of childhood); bone formation; muscle development; hormones production. . minerals: calcium and phosphate: . bone formation . muscle activity . growth problems iodine: . goitre . skeletal problems . metabolic deficiencies . vitamins A, B, C, D, E: retardation of growth; weak bones and teeth; muscle degeneration (vit. E); low resistence to infections (A, C). Sanitation and Health - House hygienic conditions - Water purification - Drainage systems - Control of communicable diseases - Child health centres - Open areas Family support - parents attitudes - relationships with siblings - access to learning facilities . toys and games . books . mass media

Topic	Conceptual Structure
	Education - access to play school and school - access to other learning environments . zoos . parks . museums . clubs . sports areas
<u>Development in puberty and adolescence</u> Sexual maturation	Nervous and regulatory systems integration - Co-ordination of hormonal production . hypothalamus: control: posterior pituitary gland; adrenal medulla. . anterior pituitary gland: stimulation: . adrenal cortex . ovary . testes . thyroid gland . adrenal cortex, ovary/ testes, thyroid: supression: . anterior pituitary gland hormones. Physical growth - adrenal cortex: . androgen - throid: . thyroxin - pituitary: . growth hormone Sexual maturation - gonads development . anterior pituitary gland: gonadotrophis (FSH and LH): . ovary/testes maturation - production of sex hormones . ovaries: estrogen; progesterone. . testes: testosterone. . adrenal cortex androgens.

Topic	Conceptual Structure
	- role of sex hormones . growth of internal sexual structures . development of secondary sexual characteristics . co-ordination of menstrual cycle . production of sperm.
Psycho-social maturation and environmental influences	Emotional changes related to - body changes - sexual maturity . adjustment to personal sexuality . sexual attraction - links to peer groups . common interests - family structure . breaking away from the family . personal independence - society structure . need of integration: small communities: . role in the family pattern of activity . integration in the community: rites of passage . developed societies: . lack of definite role in the family . lack of society support for engagement in productive roles . establishment of a youth sub-culture.

Educational Outcomes	Biological Principles
An understanding of the importance of sexual reproduction as the basis of variation within the h human species.	Sexual reproduction produces a wide range of variation among the individuals of a same species.
An understanding of the mechanisms of transmission of genetic traits and their significance in terms of the stability of a species, as well as the potential for change.	Variations among the individuals of a species are due to chromosomal assortment, gene recombination, mutation, and interaction between the genes and between the genotype and the environment.
Interpretation of the variation within the human species as a contemporary expression of the changes undergone by this species through time, and the interactions between the individual's genotypes and the environment.	The environment directs the selection of recombinations and mutations within the gene pool of a population.
Awareness of the importance of environmental conditions in the direction of the processes of natural selection.	
An understanding of the range of survival strategies of living things, at both the individual and species level.	The survival of the species depends on the selection of the individuals best adapted to live and reproduce in an environment.
Appreciation of the different factors (e.g. time, genetic code, environment) involved in the processes of change that result in the evoluation of new races or species.	Successive changes in the genetic code of a population's gene pool contribute for the evolution of new races and species.

Educational Outcomes	Biological Principles
An understanding that the adaptation of living beings to the environment is resultant from processes of successive changes and selection of genotypes.	The adaptation of the living beings to the environment results from the selection of hereditary variations through time.
An awareness of the complexity of the structure of populations and an understanding of the evolut evolutionary significance of this.	The structure and dynamics of a population depends on the interaction between the individuals themselves and between the individuals and the environment.
	The dynamics of human populations are regulated by natural processes as well as by socio-cultural and economic processes.
	Human populations have developed strategies for their survival and growth in adverse environmental conditions.
An awareness of the nature of the responsibility of human beings for the balance of the ecos system, and for the welfare of the human communities.	Socio-cultural and economic patterns of organisation and production have increased the efficiency of energy and resources transformation and use in human populations.

Topic	Conceptual Structure
Variation in the human species	Physical traits genetic transmission genotype general course of development range of expression of individual traits.
Genetic basis	Genotype - 23 pairs of chromosomes . genes: genetic code: . DNA structure: nucleotides: . number and sequence stability: exclusiveness of a species genetic genetic traits.
	Change in genetic code: . duplication of DNA: strands: . change in number and sequence of nucleotides: mutation
	Causes of variation within a species: - chromosomal assortment - genes recombination . crossing-over . translocation . supression (deletion)
Enviromental influences	- environment induced mutation . physical agents: radiation. . chemical agents
	Mutation . somatic cells . gametes: transmission to succeeding generation: . selection of mutant genes: alteration of the gene pool.

Topic	Conceptual Structure
Gene expression as an interaction between genes and the environment	Adaptation - Natural changes in the environmental conditions . consequences: physical changes in human structure: . reversible . irreversible: plasticity . selection of fittest pheno-types. . behavioural changes in human patterns: individual; group . cultural changes. . Man-made changes in the environmental conditions: physcial changes in the natural environment; technological advances for surmounting non-favourable conditions.
<u>Evolution of man</u> Mammals evolution	Favourable characteristics for the survival of Mammals . constant body temperature . constant activity: need of constant food supply: . diversified feeding habits. development of more efficient feeding mechanisms: . form of jaws and teeth . digestive patterns . wide range of behaviours. . maintenance of fertilised egg within the mother's body. . reduction of risks of mortality at birth . regular production of small number of off-spring: hormonal control.

Topic	Conceptual Structure
	. milk glands . more efficient feedings: . germ-free; nutritional balance; antibodies. . longer direct contact mother x child: increase of learning opportunities. Consequence: - survival of Mammals in a wide wide range of environments.
Man's ancestors	Insectivores and Prosimians - physical structure . limps and paws . vertebral column . sense organs - tree-climbing habits Later primates - physical structure . vertical column . flat thorax . head - neck balance . pelvis changes: . centre of gravity . floor (changed tail) . broadening consequences: . better forward propulsion . better lateral balance . stability in trans- mission of body weight . support to viscera . hindlimbs straightening: . transmission of body weight acetabulum - knee- ankle . feet narrowing: . sustentation whole body weight heel - bit toe - small toe

Topic	Conceptual Structure
	frontlimbs and hands locomotion . touch: grasp carrying objects; use of tools; procurement of food.
	Advantages of physical characteristics . bipedalism . detachment of objects from environment: detailed examination of objects . development of visual perception . development of more sophisticated behaviours.
From early to modern man - Changes in structure	Brain development - Increase in size of brain . change in structure of head: reducation of facial bones; frontal position of eyes; increase in size and verticality of forehead.
	- Change in brain structure . primitive part of cortex reduced: diminishment of sense of smell. . neocortex increased: development of sensory and motor functions: . sight . visual and auditory memory . sensory-motor co-ordination . bilaterality and fissures: improvement in cerebral efficiency; diversification of functions; higher mental processes; more sophisticated behaviours.

Topic	Conceptual Structure
	Hands structure - opposable thumb . characteristics: length strength; rotation. . advantages fine, strong grip; efficient use of tools; possibility of making tools. Hands free from locomotion - more efficient . carrying of objects . use of tools . tactile and visual perception - advantage . possibility of making tools . mouth free from carrying objects: favourable conditions for the development of speech. Vertical posture - bipedalism and body weight distribution . easy locomotion on ground . far-reaching sight . favourable conditions for hunting: development of more precise actions towards a goal.
Adaptations to new environments and cultural behaviours	The early dry environment (savannah) - hunting for compensating scarcity of vegetable food . development of co-operative behaviours: defensive; offensive.

Topic	Conceptual Structure
Socio-cultural strategies for survival	Adaptation to more temperate and colder climates - development of protective strategies for survival . sheltering . clothing . storage of food: use of containers; hunting of large animals: . meat preserving techniques. - development of grouping strategies . organisation of social life: kinship structures. Socio-cultural organisation - division of labour - sex differentiation . man - hunting . woman - gathering food; collecting water and fuel; care for offspring. - efficiency in conversion of energy into food . trapping of migratory herds . fishing groups long-staying around water courses . farming and domestication of animals: more sedentary life. - territorial and economic organisation . settlements: reduction of competition; broadening of social group interactions . more structured groups: tribes; chiefdoms.

Topic	Conceptual Structure
Spread and growth of human population	Socio-cultural interactions - cultural transmission . intra-group . inter-group - learned behaviours - evolution of language - biological effects . increase of gene flow: variation . spread of population in a wide range of environments. Socio-cultural evolution - instruction and language . communication widened . overcome of selective pressures . survival by technical adjustment: minimisation of natural hazards; change of environmental conditions; survival of populations. Mechanisms for survival of populations - Natural processes . balance between demands and availability of resources . birth rates . favourable environmental conditions . overcome of natural hazards: floods; draughts. - Cultural processes . anticipation of threats . compensation for problems . low competition . avoidance of conflicts

Topic	Conceptual Structure
. Population control	Population control strategies - Natural processes . fertility of female members . length of menstrual cycle . length of lactancy: supression of ovulation. . ill-health . epidemics . drastic environmental changes: shortage of food; draughts; earthquakes. - Cultural strategies birth control: sexual abstinence; sexual segregation; contraception; absortion; taboos; law; religious committments; education; infanticide; senilicide; warfare.
Population explosion	Population explosions in the history of man - invention of tools - development of farming nucleation by intensive farming: economic interactions; sharing; exchange: . intense personal contacts. land-dependent economic organisation abundant land: . flexible organisation . residential mobility.

Topic	Conceptual Structure
	scarce land: limited availability of resources; limited redistribution of people; stress and insecurity; tight social organisation: . kinship/lineage structures: rules; trust; productivity. . personal relationships patron-client; slavery; hired-labour. . development of institutions. industrial revolution development of sophisticated technology: efficiency in production; improvement of the living standards: . housing . sanitation . social services: health and welfare education.
Causes and consequences of overpopulation	Overpopulation - Causes . physical increase: size of population; demands of resources. . excessive work requirements: decrease of productivity - Consequences . development of new technologies . expansion of productive productive activities . development of socio-political networks . tight group structure

Topic	Conceptual Structure.
	- Strategies to counteract overpopulation . demarcation of territorial boundaries . redistribution of people . prevention of loss, misuse or waste of resources . development of exchange networks . redistribution of resources

The scope and depth of a curriculum depends on a wide range of factors that interplay within a given context. It was decided in the above curriculum to offer a comprehensive suggestion of conceptual structures from which can be drawn the most suitable structures for individual courses.

CHAPTER 9

TEACHING METHODOLOGY

There are many ways in which human biology might be taught. The particular methods selected will depend on the perspectives of the teacher and the students, on the availability of curriculum materials, and on the cultural context in which it is going to be taught.

In this part of the book references are made to ways which have been observed and used in different schools, particularly in Brazil. Suggestions will be made to simple practical activities which teachers and pupils can do in the classroom. These suggestions are an attempt to provide alternative resources for those schools which lack "already made" audio-visual aids and laboratory materials.

The Teaching of "The development of the human individual"

In Chapter 2, the process of development is looked at in two stages: the stages of intrauterine development and the stages from birth to adolescence. In both emphasis is placed on the relationships between the biological path of the process and the influences that the environment exert on that path. For many teachers this approach may be regarded as difficult to tackle at secondary school level. Some reasons for this view may be:

(a) the impossibility of demonstrating the process in the classroom, unless a film is shown;

(b) many students find models illustrating the whole process very complex;

(c) there is a lack of curriculum materials which treat the topic in an integrated way;

(d) the school syllabus and programmes do not usually include the study of infancy and childhood as part of biology courses;

(e) a tendency to study the human body in terms of its structure and functions rather than in terms of its growth and maturation;

(f) the teachers have no expertise or training for planning holistic courses.

Recently the development of society-related biology courses has been advocated by biological education specialists (see, for example UNESCO, 1977; Kelly and Shaefer, 1980). Human biology, which can bring together natural, socio-cultural and economic aspects of the environment, related to the physical growth and maturation of the human beings lends itself well as a basis for the development of such courses. A human biology, society-related approach to the construction of biology courses can make such courses more meaningful to students and overcome many of the difficulties teachers anticipate in teaching human development in a traditional context.

A number of ways which can help teachers make the study of this human development more interesting and relevant to the pupils, are as follows:-

1. Where there is a possibility of photographs of a foetus at different stages of development, these can be observed by the students, alongside a model of the female reproductive system. The pupils can observe and discuss the changes that take place in the embryo/foetus and in the mother's body at different stages of pregnancy. Relationships between the mother's state, age, health, nutrition, etc can be introduced during the discussion.

2. Observation of the development of fertilised chicken eggs at different stages can be made, to help students appreciate the different stages of development. The differences between the chicken and the human embryos can be discussed together with the relationships between the new individual and the immediate environment.

3. Construction of plasticine* models of different stages of the embryo, and of a uterus with an implanted embryo, etc. can compensate for the lack of other kinds of materials, such as those referred to in the above two suggestions.

4. Interviews with pregnant women or visits to families in which babies are being expected, may be carried out by individual students as extra-class work. These activities are useful when the object is to explore how different families get organised to receive a new member, what rearrangements in the family are necessary for this; and what kind of support a family may be receiving from the community.

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* Plasticine might be replaced by a dough made out of paper (tissue paper or newspaper), a small amount of water and a small amount of wheat flour).

5. Visits to a maternity unit of a hospital, where there is one, or to a family with a newborn are useful for the students as an opportunity for getting first hand experience on how newborns look and how they are cared for. This is particularly recommended for pupils which do not have the experience of newborns at home.

6. A role-playing session where sketches of different situations related to the embryo/foetus development, the climate of the family just before and during a delivery, the mother's feelings and body changes during pregnancy, etc. are useful opportunities for the students expression of their understanding of what they have been studying.

7. An inquiry into how a newborn is cared for by the family, in a maternity unit, by a midwife; how the newborn relates to the mother; his/her routines and common behaviours. This kind of inquiry can help students to understand how complex a task it is to care for a newborn, and the responsibility involved in the prevention of disease.

8. A survey of differences in characteristics and behaviours at different stages of development - e.g. height; weight; size of the head; body proportions - head, trunk and limbs; diets; kinds of activities children carry out: daily routines; public services they use - school, child clinic, welfare offices, parks, etc. Surveys on these aspects provide the students with chances to recognise the occurrence of general patterns in physical characteristics and behaviours of people at different stages of development. These surveys can also be important sources of simple data on differences of characteristics and behaviours of people at different stages of development within a same socio-cultural context.

9. Interviews by students with doctors; nurses; play-group teachers and school teachers; health visitors; social workers; etc. can be motivating and give pupils knowledge about professional services that are available to pregnant women, newborns, infants, children and adolescents. These kinds of activities might also bring out ways in which these professional people care for their clients, what kind of responsibilities they hold and how they help individuals to cope with their needs and demands. They can be a basis for providing students with evidences and ideas of socio-cultural, economic, scientific and technological influences on the growth and maturation of the individulas.

10. The construction by students of charts, graphs, posters, drawings showing general patterns of development at different stages (these representations may be based on inquiries or surveys, for example), is a useful kind of activity to lead pupils to observe peoples' characteristics and behaviours more closely and to discuss about them.

11. The building up of a community model (made out of plasticine, clay, cardboard, etc.), stressing the people at different stages of development according to physical characteristics (proportional sizes; body proportions; head features, postures), socio-cultural patterns (ways of dressing; personal adornments; kinds of activities they do). This kind of activity can help students to look for general patterns as well as subtle differences among people, the ways in which they relate to each other and to their community as a whole.

12. Physical activity in the form of games can provide pupils with opportunity for appreciating the work of bones and muscles. They will also enable the pupils to appreciate the effects of physical effort on the whole body - e.g. sweating, increase of body rythms (breath, pulse rates and temperature) tiredness, thirst, etc. These effects can be discussed and related to the importance of these kinds of exercises for the growth and development of an individual.

13. Search for information in reference books, newspapers and periodicals; drawing and the setting up of an informative mural are a range of activities which can be used for several purposes, such as: relating aspects of development to environmental conditions; presenting the kinds of problems that people might face at different stages of development; pointing out evidences of genetic determination of developmental characteristics.

14. A group discussion on the biological changes that take place in late childhood and puberty, and their impact on the child's and adolescent's behaviour. This can be used for raising some of the issues that are of concern to the students and give them opportunities for talking about and understanding these changes within a scientific frame of reference. The issue of the influences of technological development on society and its effects on the styles and quality of life may well be integrated in this activity.

15. Long term student projects may be carried out, involving a search for data in different segments of the community - hospitals, health units, child clinics, child care offices, welfare offices, families, police stations, play-groups, schools, voluntary groups, creches, baby minders, etc. This kind of project can be done by single students or small groups, each one in charge of one or a few tasks. In this search the students have the opportunity to discover how society perceives its responsibility towards its members, particularly those who are at the earlier stages of development.

It is not difficult to interest students in these topics, especially when they are taught other context of human biology. However many teachers have found difficulties in handling the teaching of topics such as variation and evolution. These difficulties seem to stem from the already well established views of the natural world that the students bring with them to the classroom. The commonsense view that children often have is that life does not change - in an evolutionary sense. In a human family one points more often to the similarities between the generations, rather than differences. Where the students have a tentative view of evolution, they tend to put a lamarckian style explanation on the processes of change, rather than a contemporary one. It is not easy to give students first hand experience of change over time that supports an evolutionary view of man. It is also important to recognise that an understanding of the appropriate genetics is dependent upon mathematics as well as biology.

It seems difficult to find more "concrete" means to teach a topic such as human evolution. Films and slides are interesting audio-visual aids (particularly the former), that can facilitate the grasp of ideas related to adaptation, evolution and population dynamics. However, most schools in developing countries are not well equipped in this respect. Some creative ways of dealing with the whole of this subject are needed by teachers in poorly equipped schools. Some of the ways which may be possible in poorly equipped schools are shown below.

1. The study of variation in the human species can start with the exploration of the diversity of traits within the group of students in the classroom. The construction of lists, tables and graphs casting the data collected by the pupils on traits such as colour of eyes, hair, skin; height; size of the head, fingers and nails; shape of the eyes and nose; presence of birth marks, amount and distribution of hair on the body; texture of hair and skin, etc.

2. The students can also make pedigrees of a few families in the community, trying to find out genetic traits which are common for all the families and those which are different between families and, also differences between members of each family. These common traits may be related to environmental characteristics, such as tanned skins with the intensity of sun light; good muscle development to the kind of activities people do - hard manual jobs, obesity to the eating habits, etc. In this way students can perhaps learn to differentiate those traits which are predominantly genetically determined from those which are influenced by the interactions of the individuals with the environment.

3. In schools where there is an open area, a little garden, or even a possibility to keep plant pots in the classrooms, it is worthwhile to set up some long term experiments using local plants of short life cycle, such as peas, beans, maize, etc. Different varieties of each plant can be chosen and a few individuals of each variety can be grown in different environmental conditions, so that the students are able to distinguish the predominantly genetic traits from those which are influenced by the environment (such as shortage of water and nutrients; too much or very little sunlight; restricted space for growth, etc). The observations made by the students can provide data as a basis for discussion of the causes of variation in the phenotypes and, from this, an understanding of relationships between genotype and environment can be developed.

4. If it is possible to keep small animals, such as mice or hamsters in a school, it is interesting for students to study the animals characteristics in terms of the common genetic traits and the differences between individuals from same parents. A long term follow-up of different generations from different ancestors, under different conditions can help students to understand better the existence and causes of variations within a species.

Suggestions 3 and 4 are aimed at compensating for the impossibility of directly investigating long term change in man. These activities can provide students with some concrete experience in doing a follow-up study of different species under different environmental conditions and the opportunity to grasp the fundamental ideas related to the interaction genotype-environment. However, it is advisable that these experiments are used as the basis for extrapolations into the occurrence and expression of these processes in the human species.

5. The building, by the students of an informative mural on the variation of the human species through the world can be a very active and motivating activity. Students can search for information from sources such as newspapers, magazines, books, and travel agencies prospectus. The adaptive features of human groups in relation to the environments in which they live, together with a study of human migrations can form the basis for discussing gene flow in the human species as well as cultural interaction.

6. A study of man's evolution can be enriched with activities such as role-playing, when sketches on different stages of human evolution can be performed by the students (e.g. how cave man, hunters-gatherers and first farmers used to live, the organisation into groups, and the relationships within the ecosystem).

7. The construction of a flow-chart of the changes in the structure of the body from man's ancestors until modern man, is an interesting way for learning about successive changes, adaptation and selection. Such learning may be more facilitated if these structural changes are placed within a time-scale and related to the use and making of tools, the development of language, the transmission of culture, and the interactions with the environment. In such a way students may take a more holistic view of the process of evoluation.

8. Discussions of "problems" that early man may have had to cope with and attempts at devising the possible ways which may have been used to solve them can help students to imagine the conditions of living and the features of ancient styles of living. Students can be encouraged to devise and make tools which could have been used by early man and to demonstrate their usefulness and significance in cultural evolution.

9. A collection of information from textbooks, magazines and other sources, on hypothetical explorations about the socio-cultural evolution of man; first settlements, farming, domestication of animals, social organisation, etc. This information can provide a basis for students making models out of clay, plasticine, cardboard; posters or diagramatic representations of those different stages. Such activities, can make such a study less abstract.

10. The presentation of a list of natural hazards which threaten the existence of human populations; their causes and possible consequences, can be used as a means of starting off a comparative study between the ways in which these hazards interfered with non-developed communities and the ways in which technological advancements have helped to minimise their occurrence and/or effects.

11. A survey in the local community about the different ways that people have developed to protect themselves against un-favourable environmental conditions may be carried out by the pupils. Styles of houses and clothes; techniques of food storage and preservation; planting and pests control techniques, are a few examples of contemporary ways used as strategies for the survival of individuals and populations. These ways can be compared to hypothetical ancient ones used for similar purposes.

12. Discussions on different ways used at home, at school and among friends for communicating and teaching one another may be an interesting way to lead the students into thinking about the importance of language and cultural transmission for the evolution of man and the integration of members of human populations.

13. The construction of flow-charts and maps showing networks in society such as those related to food production, processing, distribution, commerce and consumption; minerals extraction, transformation, manufacture and uses. The study of these networks in relation to geographical and ecological features of the community or country will help students to understand the role of farming, mining, industry and commerce for the development of human populations. Comparisons between hypothetical ways ancient man used, to produce, process and use natural resources, with the above mentioned networks are worthwhile activities. Students can build up a wider framework for the interpretation of the question of growth and balance of populations.

14. A study of statistical data (tables, graphs, etc.) on the structure of populations (e.g. size; age and sex structure; rural/urban distribution; density of population) and the identification of factors that contribute to the particular characteristics of a population (e.g. birth/mortality rates; economic activities; ecological characteristics of the area). The relationships between the two sets of information can provide students with useful pictures of the complexity of the interactions that take place within a context at a given time, and how these interactions interfere with the population's dynamics.

15. A survey of the various institutions and organised groups that integrate the population, such as religious, educational institutions, families, laws, unions, associations. Discussions on the norms, values, ethos of these institutions or groups are worthwhile in helping students to assess the influences of socio-cultural factors on the population dynamics.;

16. Meetings with community members working in different sectors of and belonging to different segments of the community (for example health: nurses, midwives; agriculture: engineers, farmers; social and welfare services: social workers, child care officers; psychologists; education: teachers, school administrators, local authorities officers; economics: economists, statiticians, public administrators). Such meetings can provide students with opportunities to understand the role of a particular service in the life of a community.

17. A debate on the consequences of technological development on the natural balance of human populations may be an interesting way in which to encourage students to assess the positive and negative aspects of technology for mankind.

In putting the activities suggested above into practice it is advisable to develop them first in the particular context of the students own communities. It is worth to take into consideration, where appropriate, the following aspects relating to the community:-

(a) the kind of ecosystem, emphasising the components and products which are used as basic nutrients; the climatic conditions; the sources of water; the balance in this ecosystem: pollution and mutational agents; endemic diseases sources;

(b) the socio-economic context, mainly the stage of development of the community; the means of production and the job market open to the population; the available scientific and technological support; the health, education and welfare services offered to the families; sanitation of the community area;

(c) the cultural norms, values, religious options, taboos, of different sections of the community;

(d) the family organisation: the size and economic situation of the family, the housing conditions; the nutritional state, feeding habits; the way they dress as related to the climatic conditions; genetic abnormalities and endemic diseases.

The study of human biology, however, should not be restricted only to a students own local community. Students need to become aware, through the study of human biology, of the wider, national and international human community. The local community will be the starting point for most educative experiences.

CHAPTER 6

RESOURCES

Annotated list of resources

One of the limitations on the teaching of human biology within a developmental and evolutionary perspective is the availability of resources. Teaching aids are available, many arising from projects such as the American B.S.C.S. and the British Nuffield Science teaching schemes. However these are often expensive, involve sophisticated maintenance, and are not geared to the sorts of teaching circumstances one finds in many developing countries. The Brazilian Foundation for the Development of Science Teaching (FUNBEC) is an organisation charged with developing materials for science teaching, and is not untypical of such organisations found in a number of developing countries. It has produced teaching materials of use to science teachers, but as yet, very little in respect to human biology. The following is a list of sources which may be available in different communities and may act as potential sources of teaching resources. The first part are resources produced by FUNBEC as examples of possible materials, the second part refers to possible sources in any country.

(a) Manufactured Resources (FUNBEC)

1. Elementary School Portable Science Laboratory

This is a portable set including a box of general materials (for the school as a whole), a box of materials for pupils' work and a handbook with suggestions of over a hundred experiments. Thirty of these experiments are on growth, development, nutrition, reproduction and other biological functions.

2. Elementary School Basic Multipurpose Science Laboratory

A set of five boxes of different materials for pupils' work, a box of general materials (for the school as a whole) and a teacher's book. The material enables a number of experiments, in topics such as metabolism, growth, genetics, populations and variation in living beings to be attempted.

3. Kit "Human Genetics"

This is a kit that provides materials for the identification of variations within the human species. Two experiments can be done with it: differences in the sensitivity to PTC, and the blood grouping (ABO system) of human individuals.

4. Secondary School Portable Biology Laboratory

This is a portable set including the same components as those mentioned above. Experiments on reproduction, food, enzymes activity, respiration, development, genetics and behaviour are suggested.

5. Kits: "Fossils" and "Variation and Evolution"

Two kits are being prepared as part of the project "Investigando a Terra" (Brazilian version of the American project ESCP). The first kit provides material for the study of the relationships between geological strata and fossils, aiming at giving the students a view of simple techniques of analysis on the history of earth and living beings. The second kit provides materials for the study of a species and the variation of its individuals.

(b) Community-based resources

The list of sources of resources that follows is aimed at offering the teachers a few ideas from which they can expand and find out many others, according to the potentialities of their own community.

1. Farms: these can provide both:

(a) opportunities for the study of some strategies that man developed for their survival - such as demarcation of land, division of labour, planting practices, techniques for rearing animals, use of sophisticated technology for increasing food production; dissemination of products for consumption;

(b) resources for practical activities, such as chick eggs at different stages of incubation; specimens of small mammals for the study of their structure, functioning and behaviours; samples of kinds of food available locally; feeding habits of the community.

Training Institutions such as

2. Schools of Agriculture and Veterinary Sciences

Biology teachers can often get a great deal of help from these kinds of school if there are any in or near their communities. Samples of materials such as seeds, plants, small mammals; different kinds of soil composts; informative prospectus on local suppliers; instruction on techniques for keeping plants and animals at schools; lists of mutational agents; lists of nutritional value of different kinds of food; results of local/national studies; techniques for development of simple experiments; information about chemicals used as preservatives, stabilisers, artificial colours and flavours, pesticides, insecticides and their effects on human individuals and populations.

3. Local hospitals, child clinics, health units, doctors surgeries

It is possible to obtain, from such services, informative materials, such as leaflets, prospectus, booklets, on issues related to human development and health; together with charts, diagrams, posters.

4. Government Offices

In many countries there are local offices including GOU offices, job centres and tourist offices which provide a great deal of information on the demography, economic structure, labour market, natural resources, climatic and other ecological features of the area. Such information can be very helpful in constructing courses in human biology.

5. Museums

In areas where there are archaelogical, anthropological, natural history or science museums the teachers can, besides taking the pupils for guided visits, often obtain a series of printed or duplicated materials on issues related to human evolution, ancient styles of living, etc. Some museums have packages of projects or curriculum materials which can be borrowed by the teachers.

6. Zoos and natural reserves

Besides guided visits, the pupils can develop individual or small group projects for the exploration of the environmental conditions in which mammals live in natural environments and in captivity. A study of monkeys and apes and other mammals can be developed where these are available for observation. Many zoos also have printed or duplicated material which can provide interesting information about the primates and their evolution, ecology and behaviours.

7. Local Teacher Training Centres and University/Higher Education Institutions in charge of Education and Biology courses

In these institutions there are a number of facilities that can be offered to teachers, such as training courses on different biology topics or themes, kits for experiments, curriculum project materials, audio-visual materials, reference books, periodicals and handbooks to be handed to local teachers.

Annotated bibliography

Examples of books aimed at the first level of secondary education in Brazil are:

(a) BARROS, C. O corpo humano: programas de saúde. 1º grau. 10ª edição, São Paulo, Ática, 1980.

(b) GOWDAK, D. Anatomia humana, fisiologia e reprodução. Ciencias, Livro 3 São Paulo, Editora FTD S.A., s.d.

(c) ZEÍNUM, R. Corpo humano. Ciências, volume 3. São Paulo, Instituto Brasileiro de Edições Pedagógicas, s.d.

At the upper level of secondary school in Brazil besides the Brazilian translation of the BSCS (blue and green versions) and the Nuffield Biology projects, a number of other textbooks nationally produced, are available, and include the following:

FROTA PESSOA, O. Biologia Nordeste. Recife, Universidade Federal de Pernambuco, Centro de Ension de Ciências do Nordeste, 1970.

One of the first Brazilian books with an attempt to integrate ecological characteristics of a region into the study of biology topics. It includes references to human biology in many chapters, mainly on those of nervous co-ordination and regulatory mechanisms, plus three chapters that deals with reproduction, genetics and evolution particularly in man. Besides the basic text this book includes extracts of fiction books and scientific texts and reports which give the pupils and teachers interesting materials for further explorations.

HENNING, G. J. e FERRAZ, G. C. Biologia Geral: 2º grau, 10ª edição. Porto Alegre, Mercado Aberto, 1981.

This book approaches biology from a general view, however the chapters related to the vegetative functions have specific parts related to the biology of man. The nervous and regulatory systems chapters have an emphasis on man, as well as those on genetics and health. Throughout the book the information is treated in some depth and there is an attempt to study some functions showing the interactions between different systems.

UNIVERSIDADE DE SÃO PAULO. Instituto de Biociências. Biologia para o 2º Grau. Rio de Janeiro: MEC/PREMEN:FENAME, 1981.

This is a set of textbooks for students together with a teacher's book. The basic concern in this text is to present biology as a study of phenomena and processes that are part of man's everyday life. Although centred on human biology, it brings together chapters on particular issues related to groups of other living beings (such as birds, insects and plants). Suggestions of simple exercises and laboratory work, using cheap and improvised materials are presented, as well as guidelines for the implementation of the course as a whole.

Sources of information for teachers in Brazil both on biological content and methodology, are usually translated from different countries and produced by international organisations. Examples of some which are available, are the following:

NASON, A. Biologia. México, Editorial Limusa. Wiley S.A., 1972. (Mexican translation of Modern Biology, New York, John Wiley and Sons, 1965)

This is an interesting textbook that covers the molecular basis of biology, the interaction between organisms and environment and a biology of higher animals, specially man. It includes in this last part a study of genetics, embryo development, reproduction, locomotion and protection, co-ordination, vegetative functions and evoluation.

PETIT, C. e PREVOST, G. Genética e evolução. S. Paulo, Edgard Blücher. Ed. Universidade de São Paulo, 1973. (série Introdução à Biologia. Brazilian translation of Génétique et Évolution. Paris, Herman, 1967).

This book has a general approach to genetics and examples on human genetics are found frequently in the text. A chapter on human evolution, points out the relationships between man and other primates, as well as references to some of the closer ancestors to modern man and contemporary human races distributed throughout the globe.

UNESCO. Libro del Professor sobre Biologia de las poblaciones humanas. (America Latina e el Caribe). Paris, Editorial de la Unesco, 1977. (There are also an African and an Asian versions of this book, whose English Editions were published in 1975).

This is a very useful book for the study of human biology, integrating ecological and socio-cultural aspects of the South American and Caribean contexts. It covers issues such as evolution, ecology, population dynamics, human reporduction and some prospective thoughts on the future of human populations. A large amount of data on both, world and regional scale and on past and present situations, provides elements for the understanding of the processes of growth and control in human populations.

UNESCO. New Trends in Biology Teaching. Paris, Unesco. Vol. I, 1966; Vol. II, 1969; Vol. III, 1971 and Vol. IV, 1977.

This series aims at providing biology teachers with a collection of information on the contents and methodology of biology, mainly related to secondary education. Some articles on aspects of human biology are published in the first volumes. The fourth volume is dedicated to the results of a congress carried out in Uppsala, Sweden in 1975.

In Volume 3[1] there is a list of institutions and periodicals related to science education in many countries as well as a chapter on the work of the Institute of Biology, an English institution that offers different kinds of support to biology teachers.

REVISTA DE ENSINO DE CIÊNCIAS

This is the only Brazilian periodical dedicated to Science Education, published by FUNBEC since 1980, which aims at providing teachers with articles on science teaching methodology, history of science, applications of science in society, environmental education, as well as specific works on different branches of science (e.g. mathematics, physics, biology and chemistry).

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(1) A similar list has been also published in other volumes but this one is the most comprehensive in the series.

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